

Tundra fire regimes of Alaska: the Holocene perspective



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**National Science
Foundation**



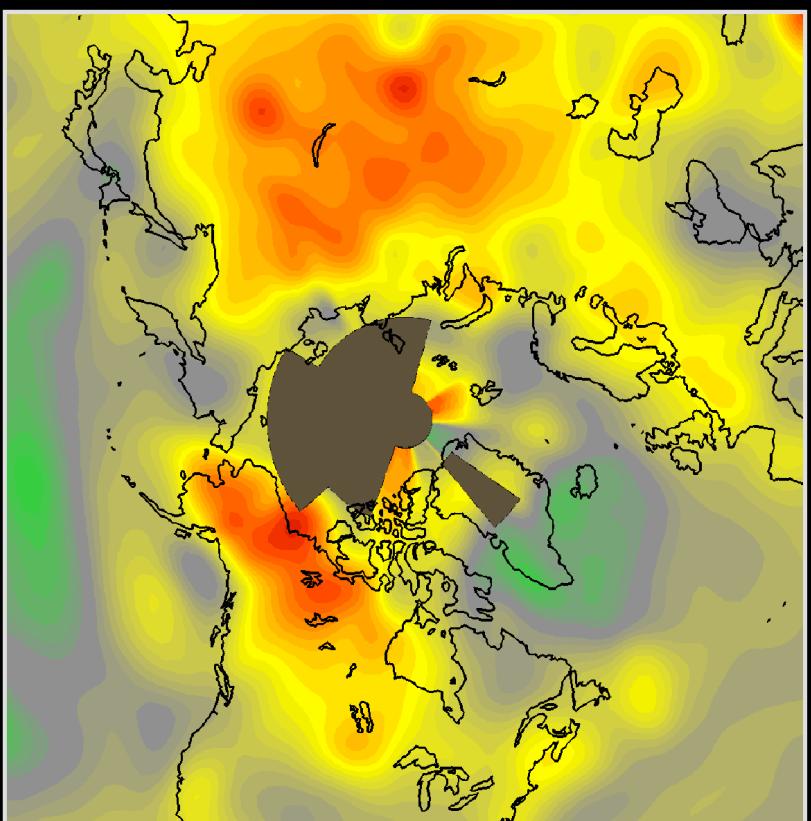
Joint Fire Science Program

Research Supporting Sound Decisions

www.firescience.gov

Surface air temperature change : 1954 - 2003

annual - °C



Shrub expansion:

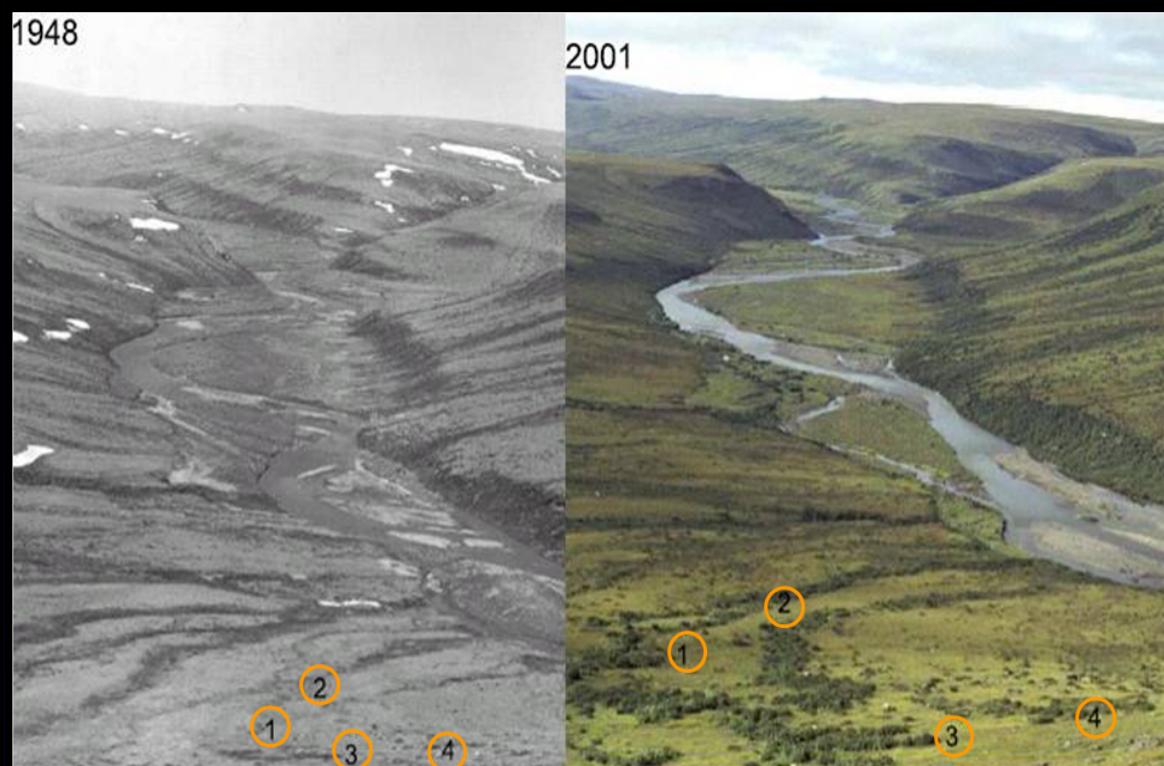
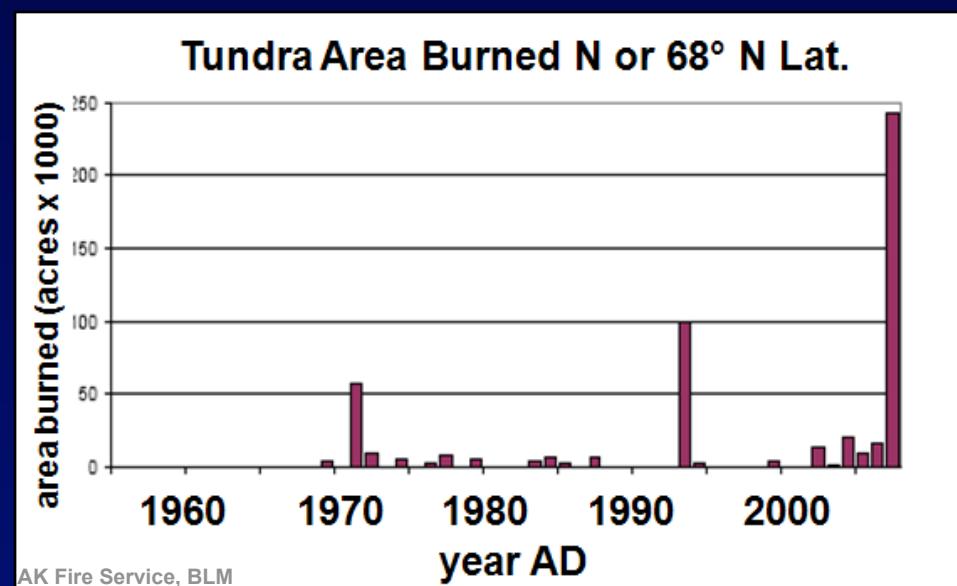
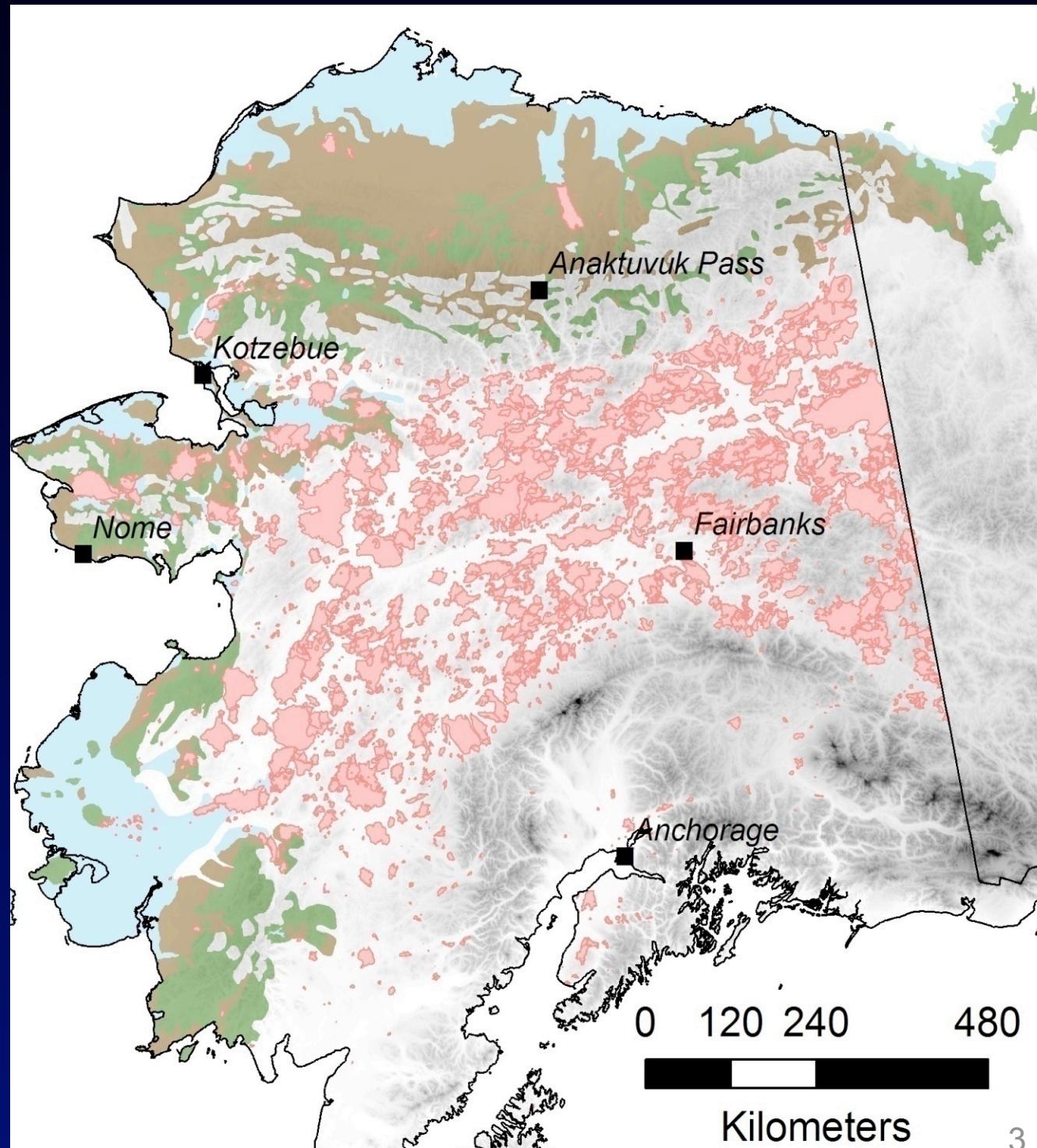


Fig. 4. from Stow et al. 2004. Remote sensing of vegetation and land-cover change in arctic tundra ecosystems.

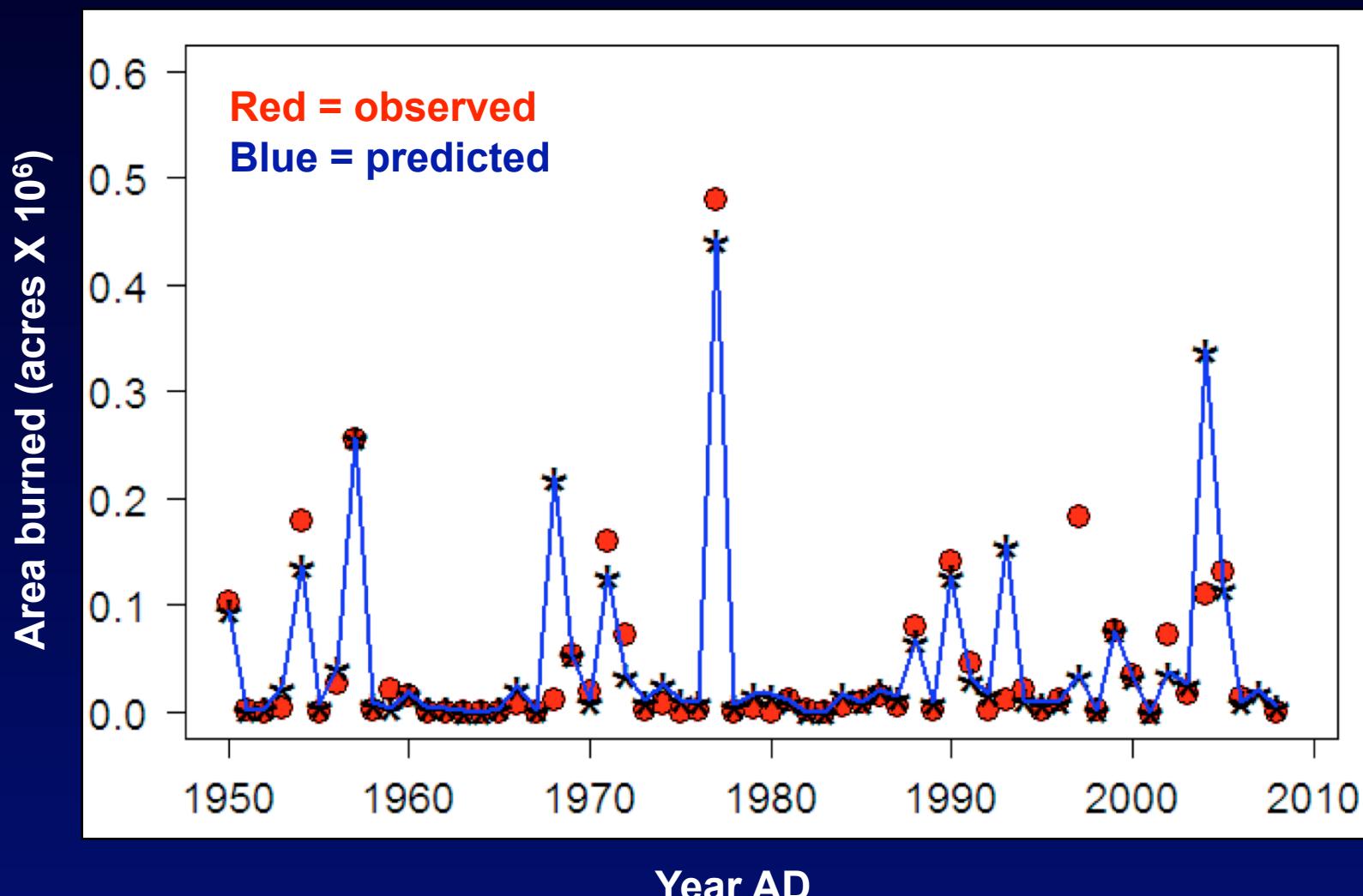
- **Will tundra area burned increase?**



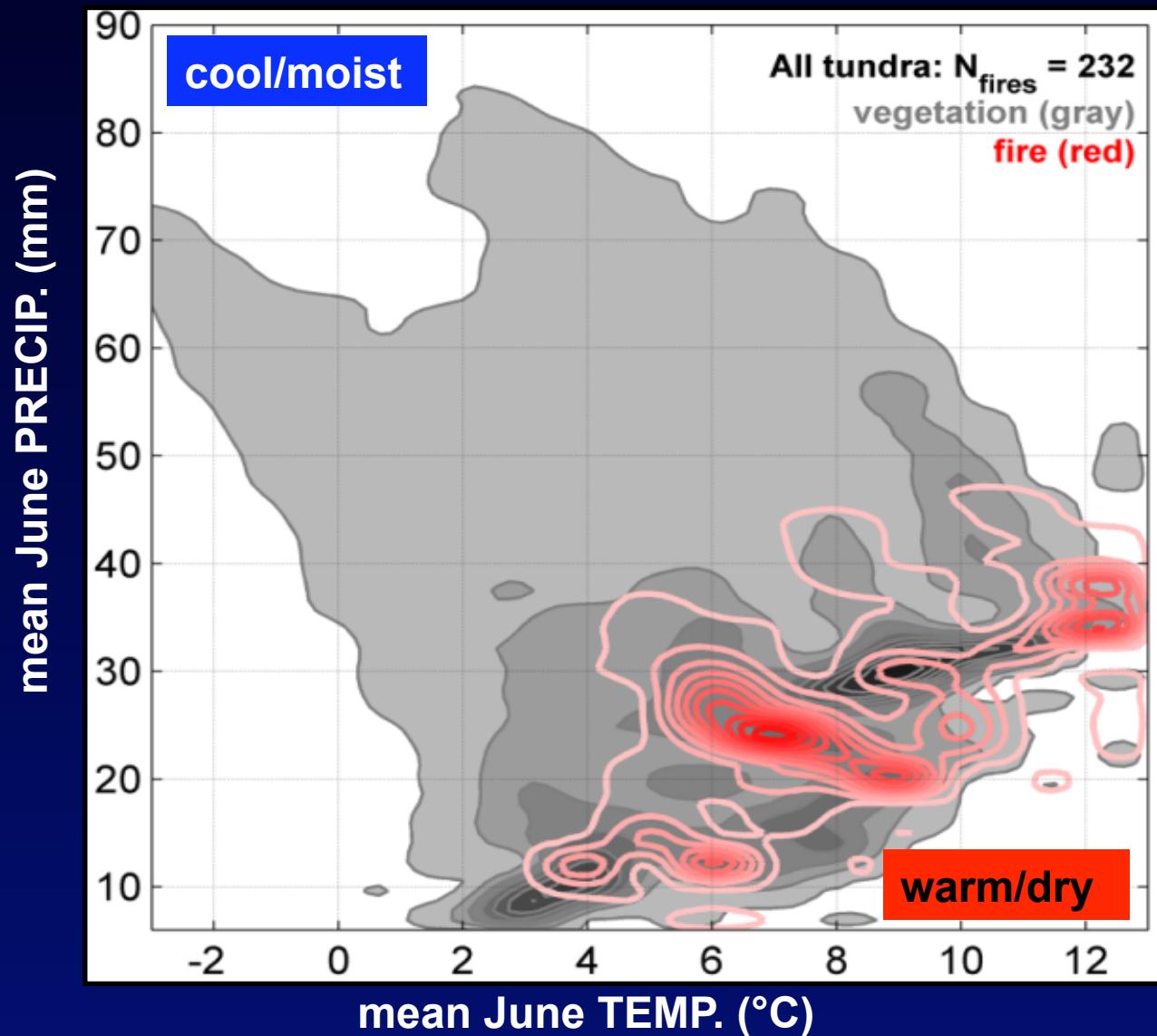
- ≈ 90% area burned in boreal forest
- > 1.8 million ha burned in tundra
- 1500 citations: “boreal forest + fire”
- 151 citations: “tundra + fire”



- Inter-annual variability explained by August temperature and precipitation (fire weather)

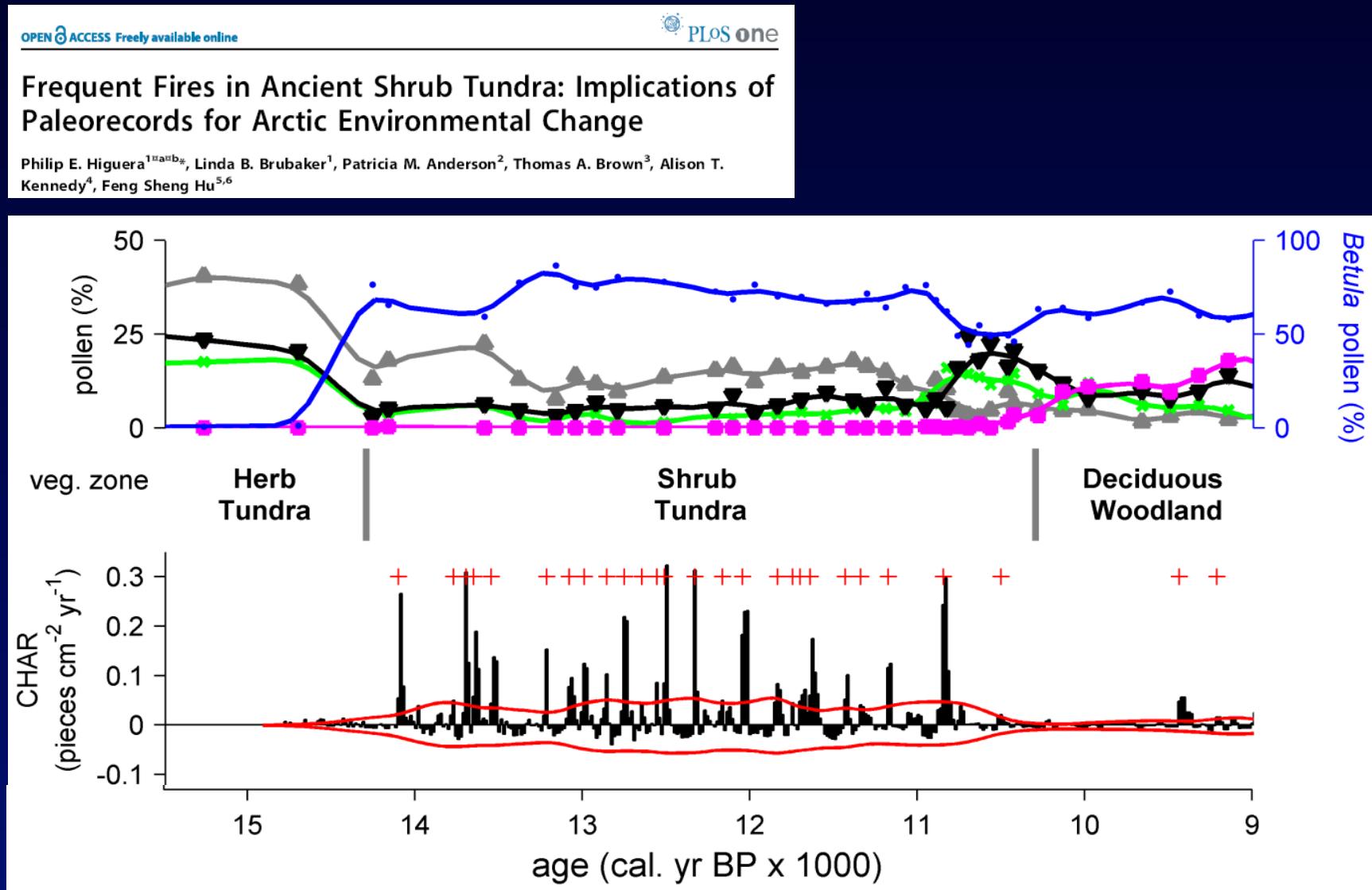


- Tundra fires occur in “warm/dry” climate space

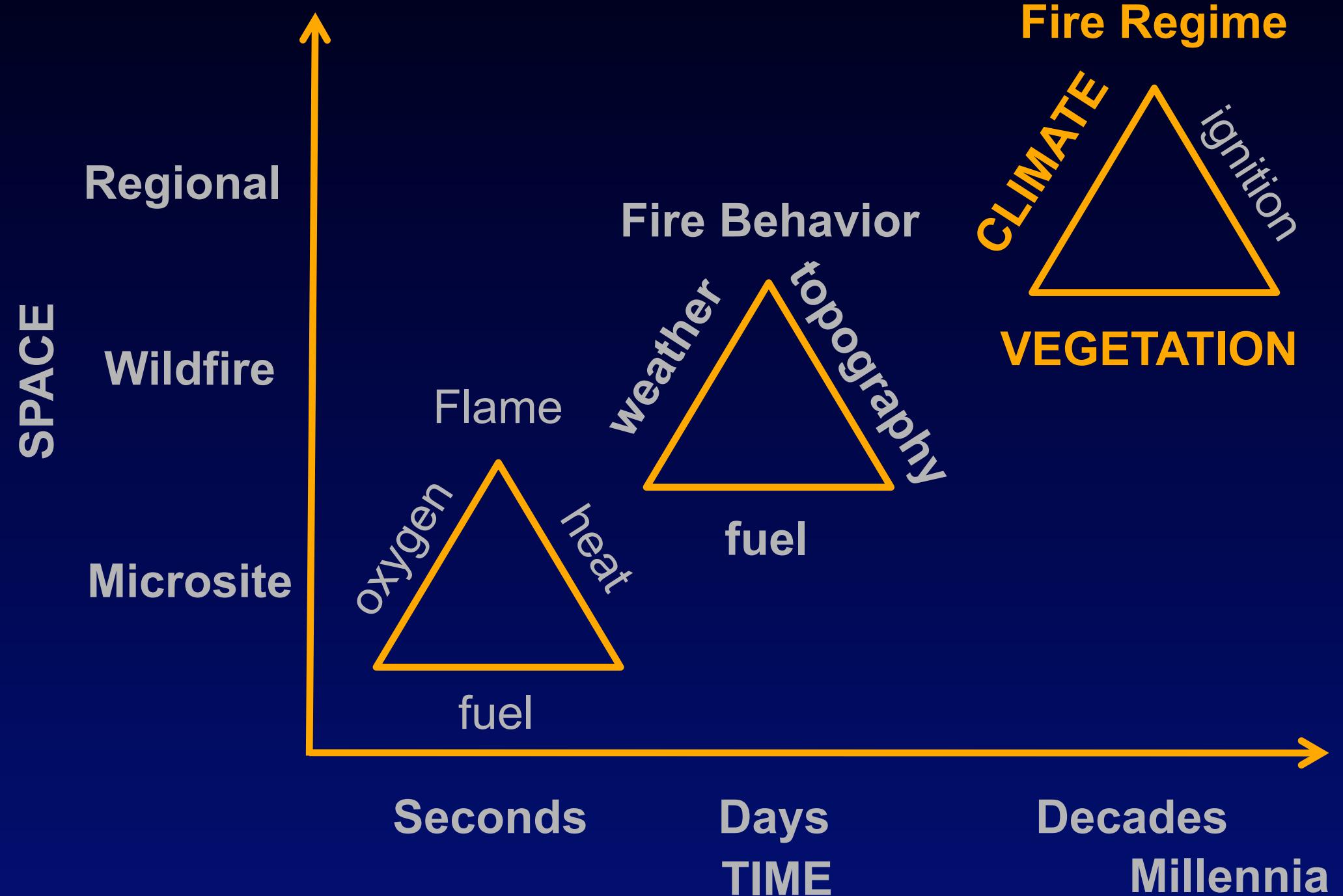


Paleo Evidence of Frequent Tundra Fires

- Tundra fire frequencies could increase with shrub abundance and climatic drying



Conceptual Framework



Reconstructing the past



Reconstructing the past

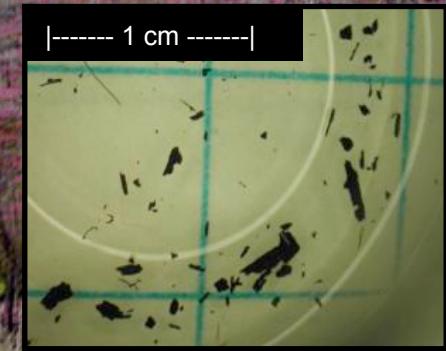
pollen:



macrofossils:



charcoal:



Reconstructing the past

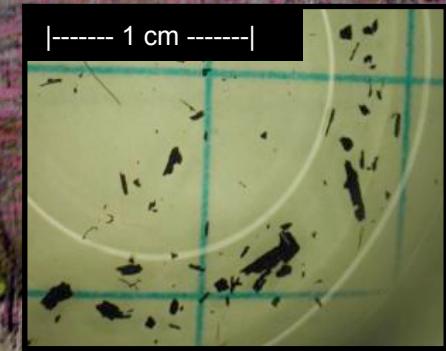
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charcoal:



Reconstructing the past

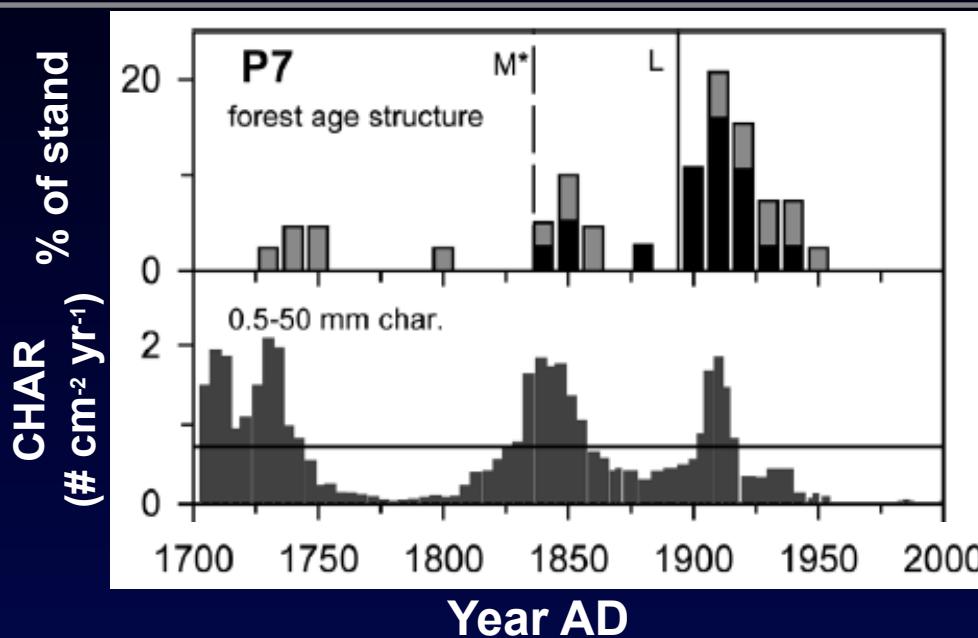


Reconstructing the past



Fire history from continuous sediment records

Empirical support:

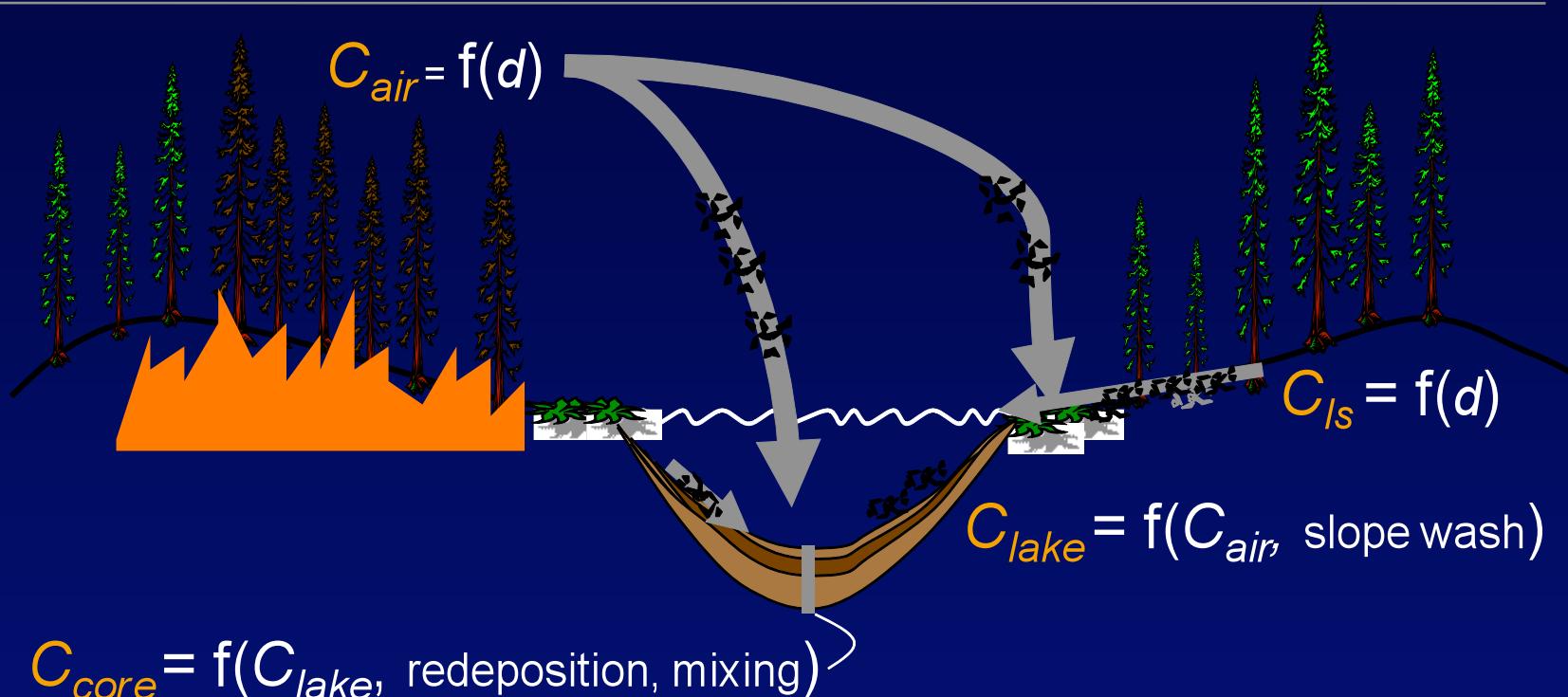


Stand age & fire scars

Charcoal accumulation

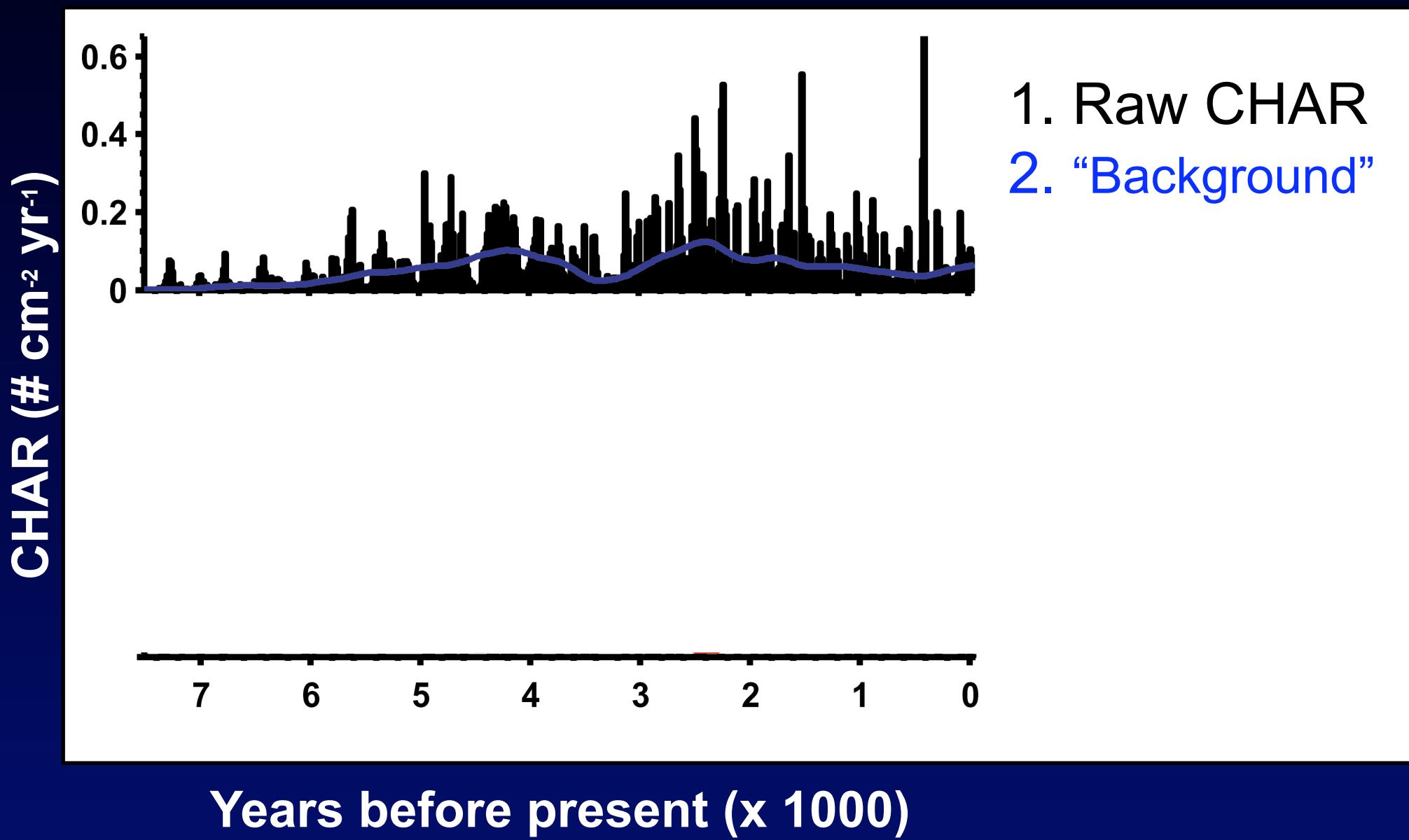
Higuera et al. 2005

Theoretical support:

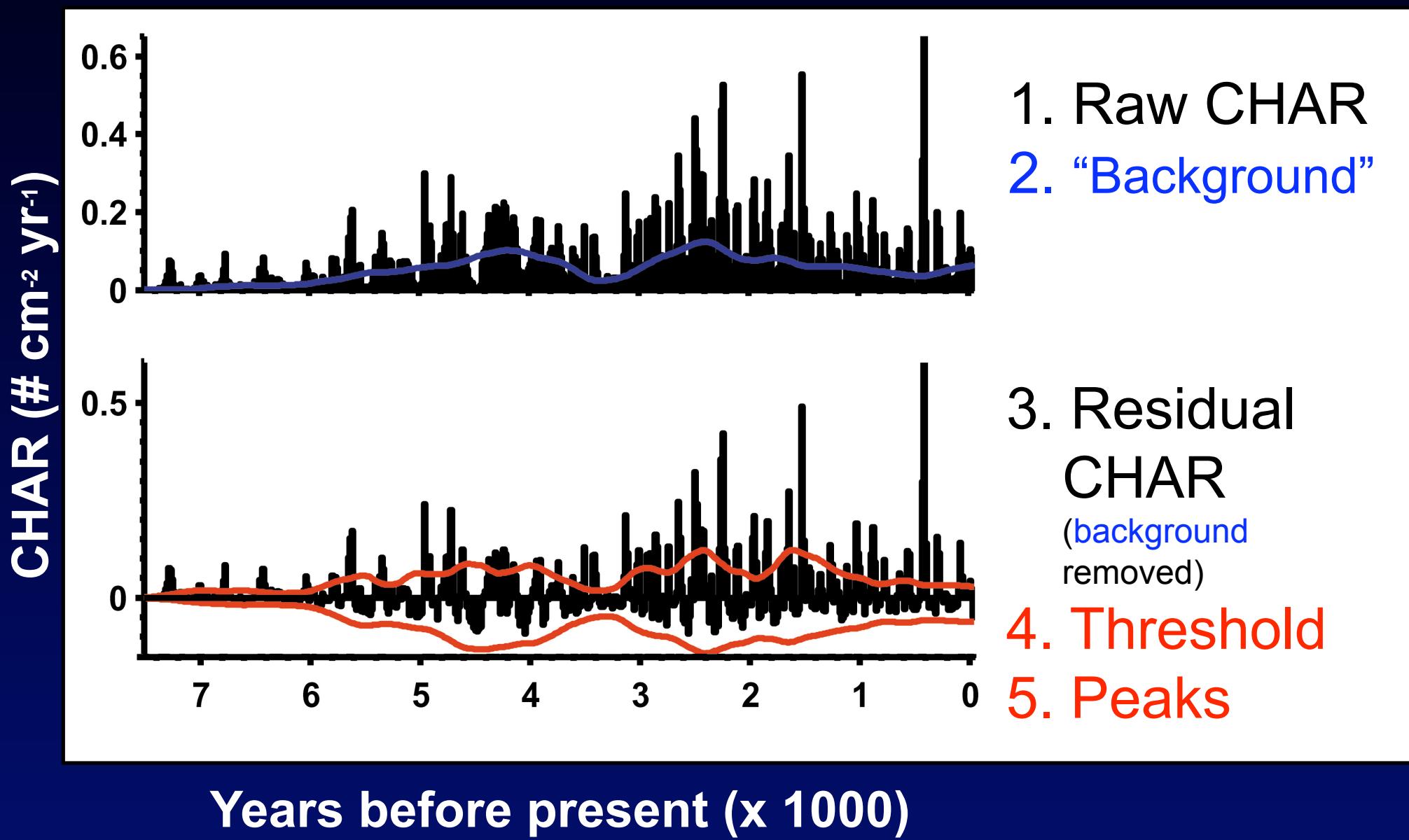


Higuera et al. 2007; Peters and Higuera, 2007

Fire history from continuous sediment records

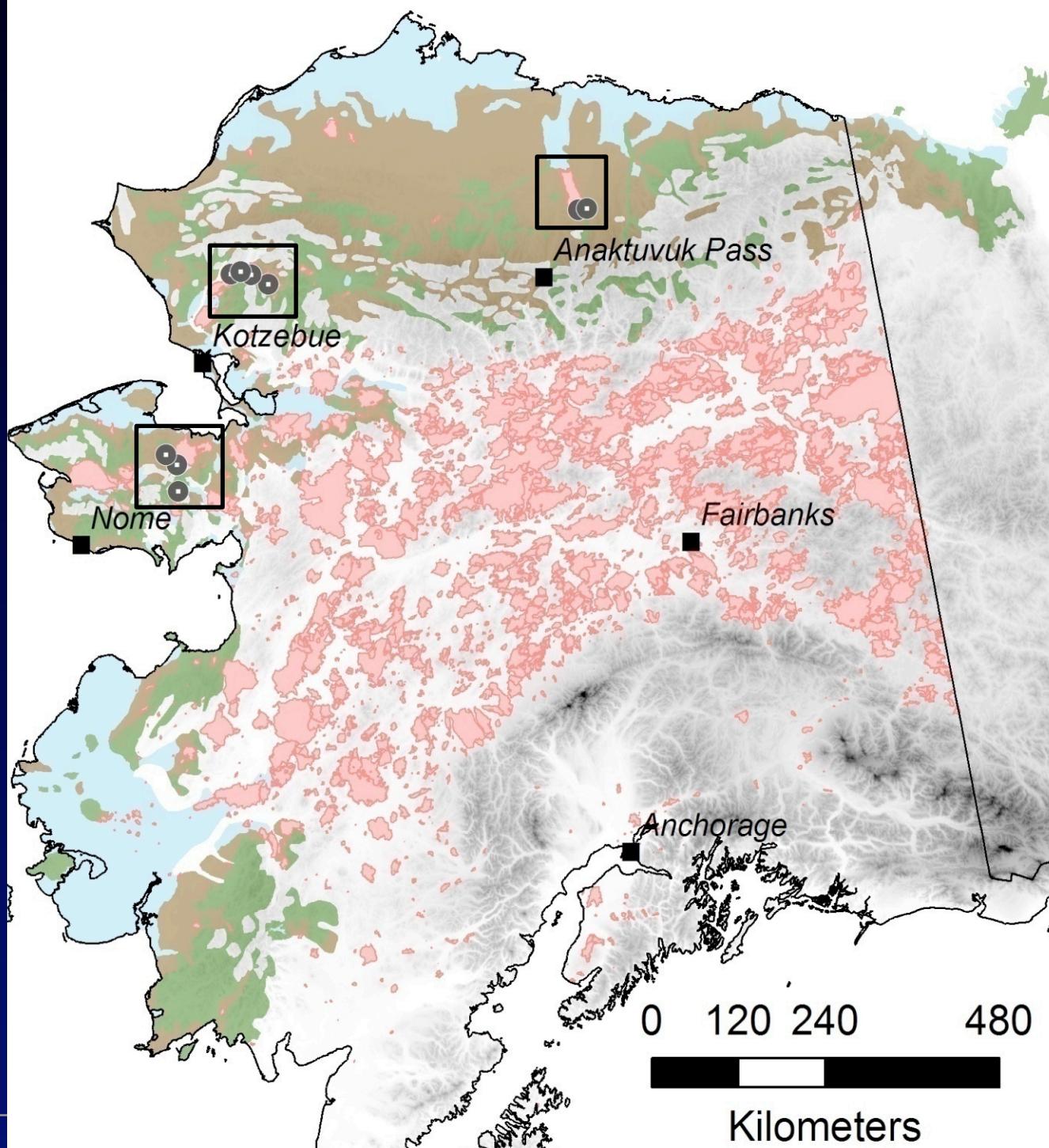


Fire history from continuous sediment records



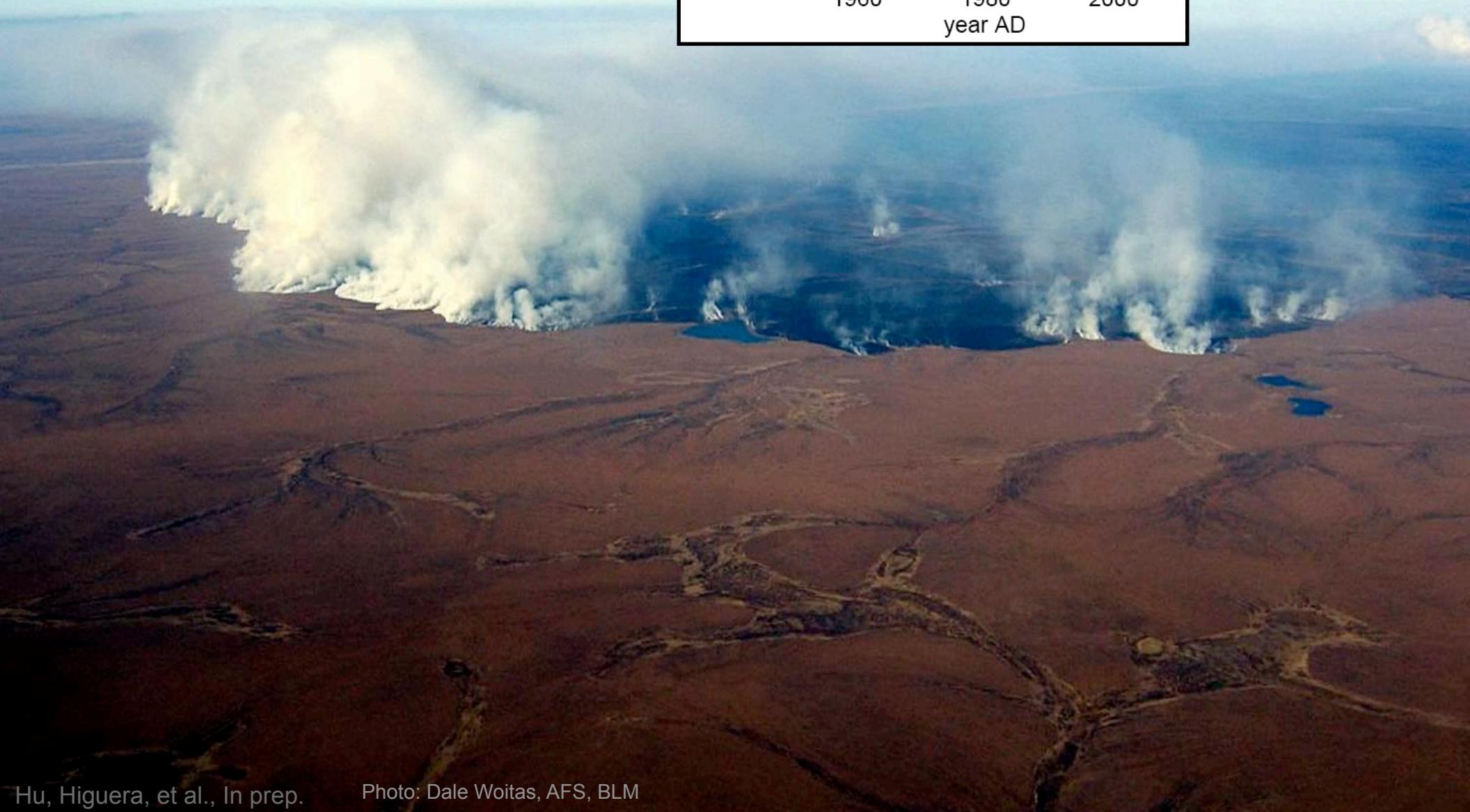
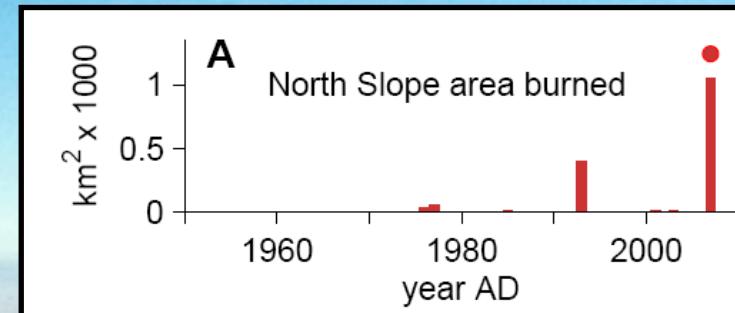
Holocene records of tundra fires

- Anaktuvuk River Fire
- Noatak NP
- Bering Land Bridge NP



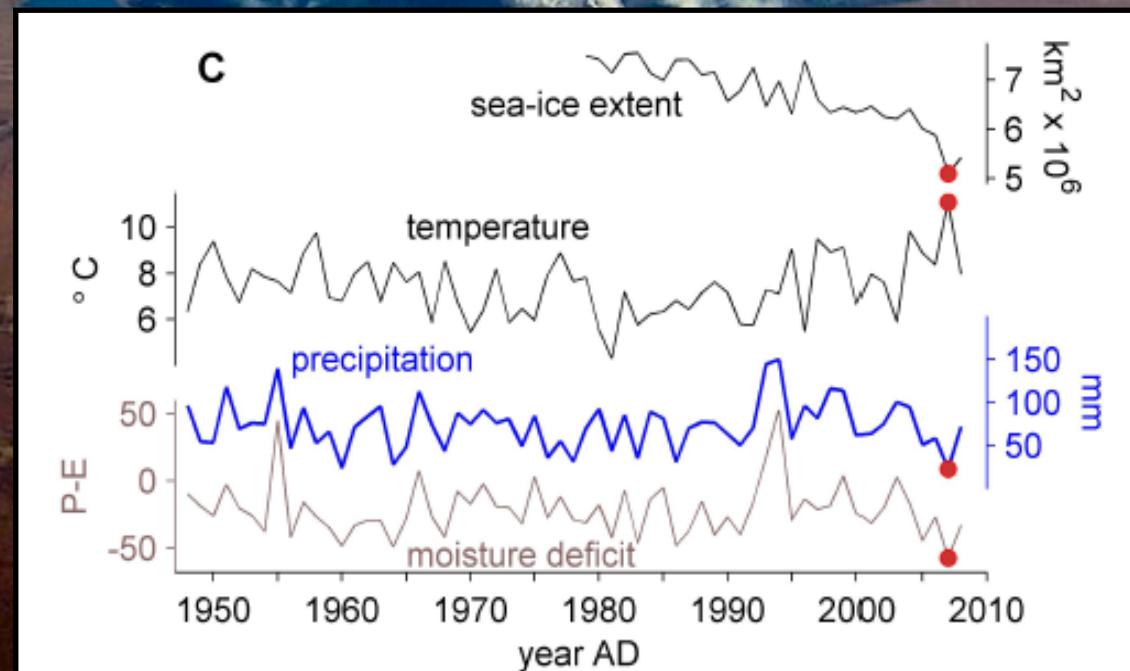
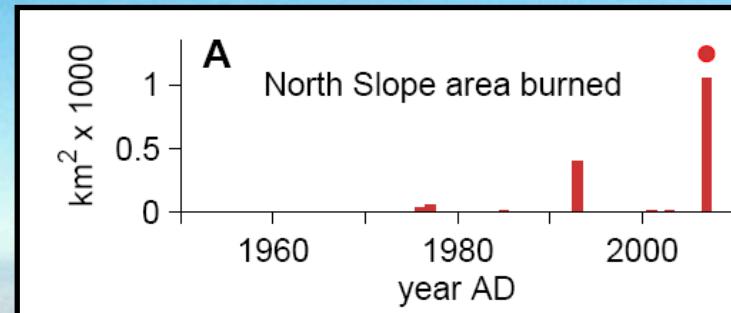
Unprecedented Tundra Burning and Possible Linkages to Extreme Sea-Ice Retreat

F. S. Hu, P.E. Higuera,
J. E. Walsh, W. L. Chapman,
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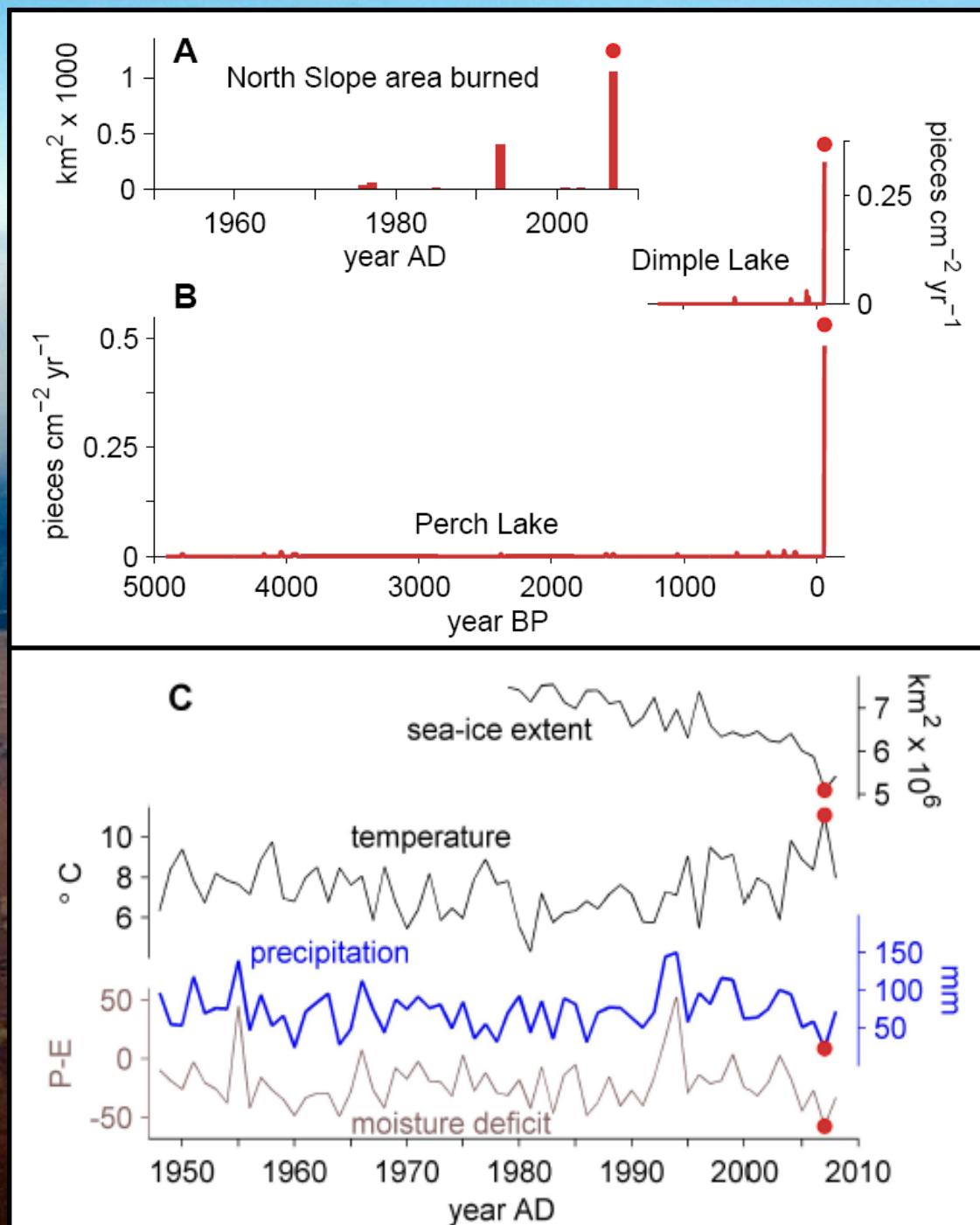
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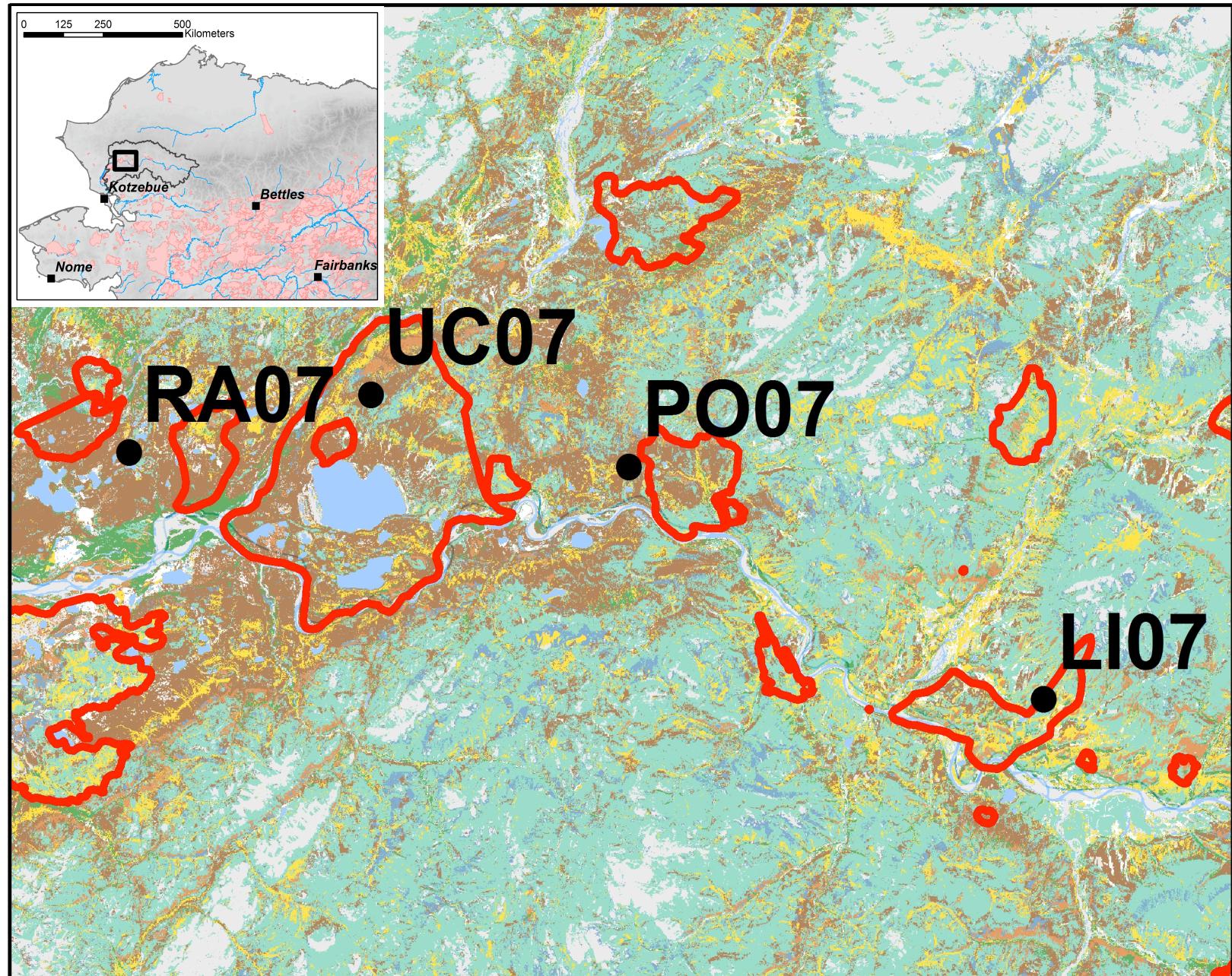
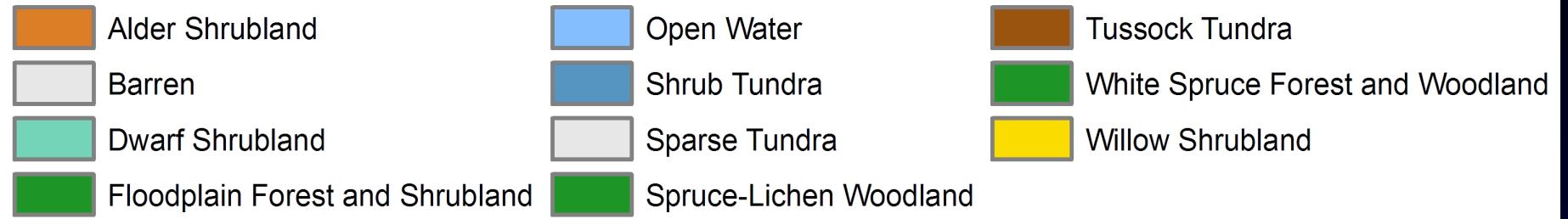
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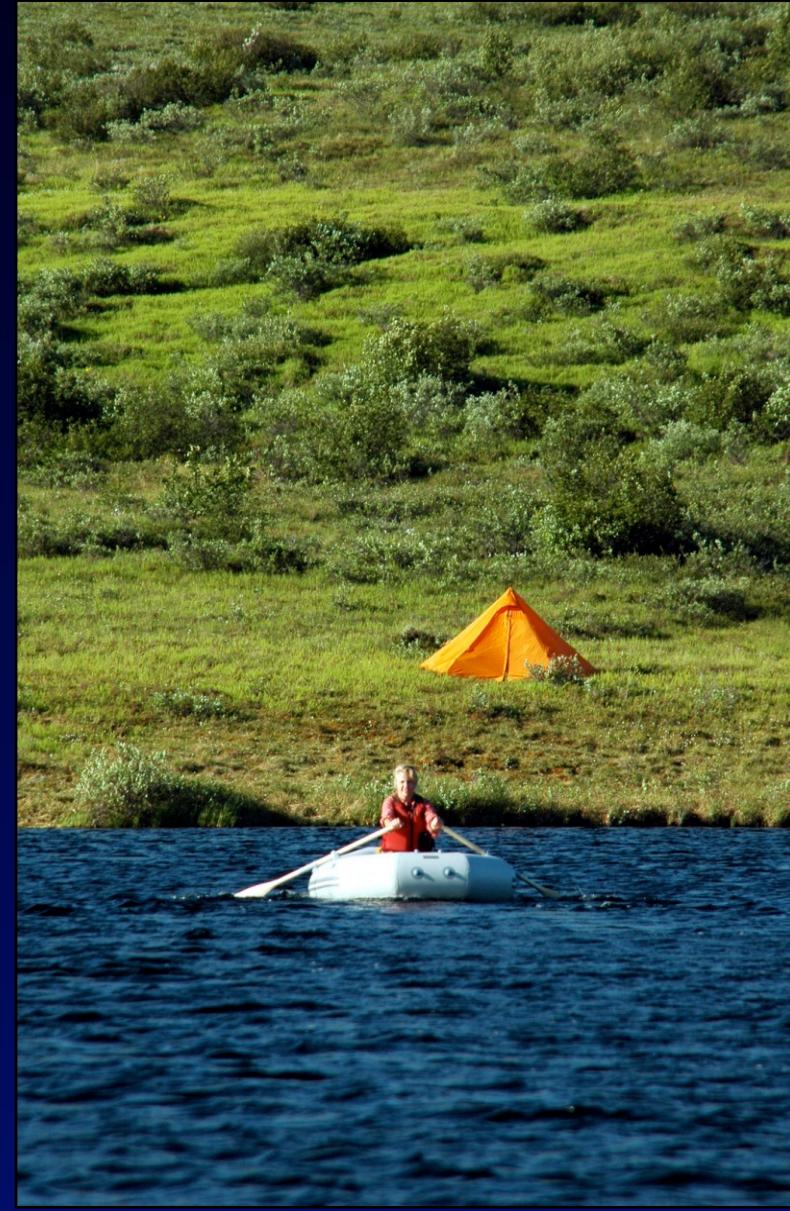


1. Quantify tundra fire history over the past 6000 years
2. Infer climate-vegetation-fire relationships from pollen and independent paleoclimate records
3. Inform ecosystem model (ALFRESCO) for assessing fire and fuels hazards in tundra under future climate / veg.

Noatak Study Area

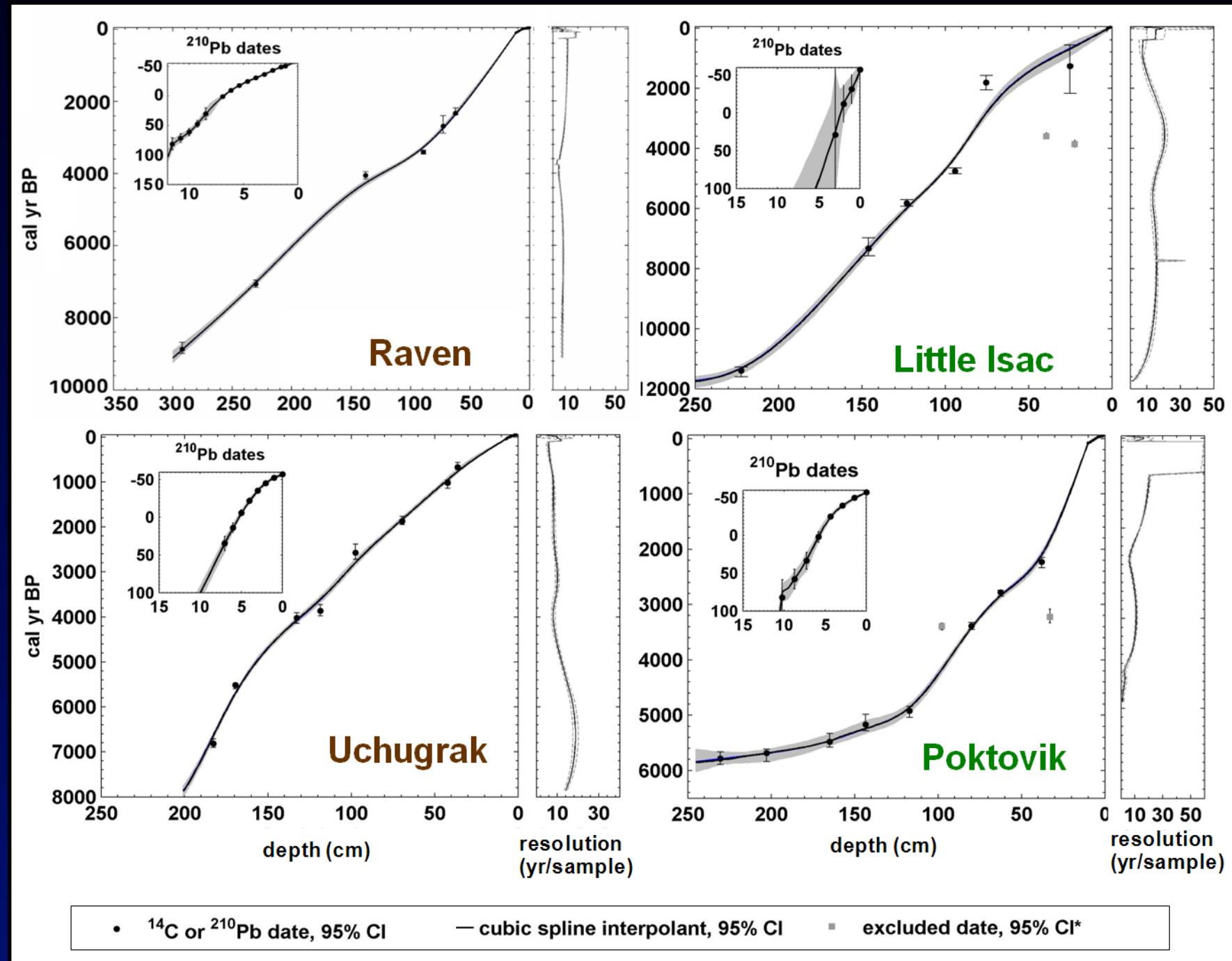


Graminoid Tundra:
Cyperaceae , Poaceae, dwarf shrubs



Shrub Tundra:
Betula, Alnus, Salix

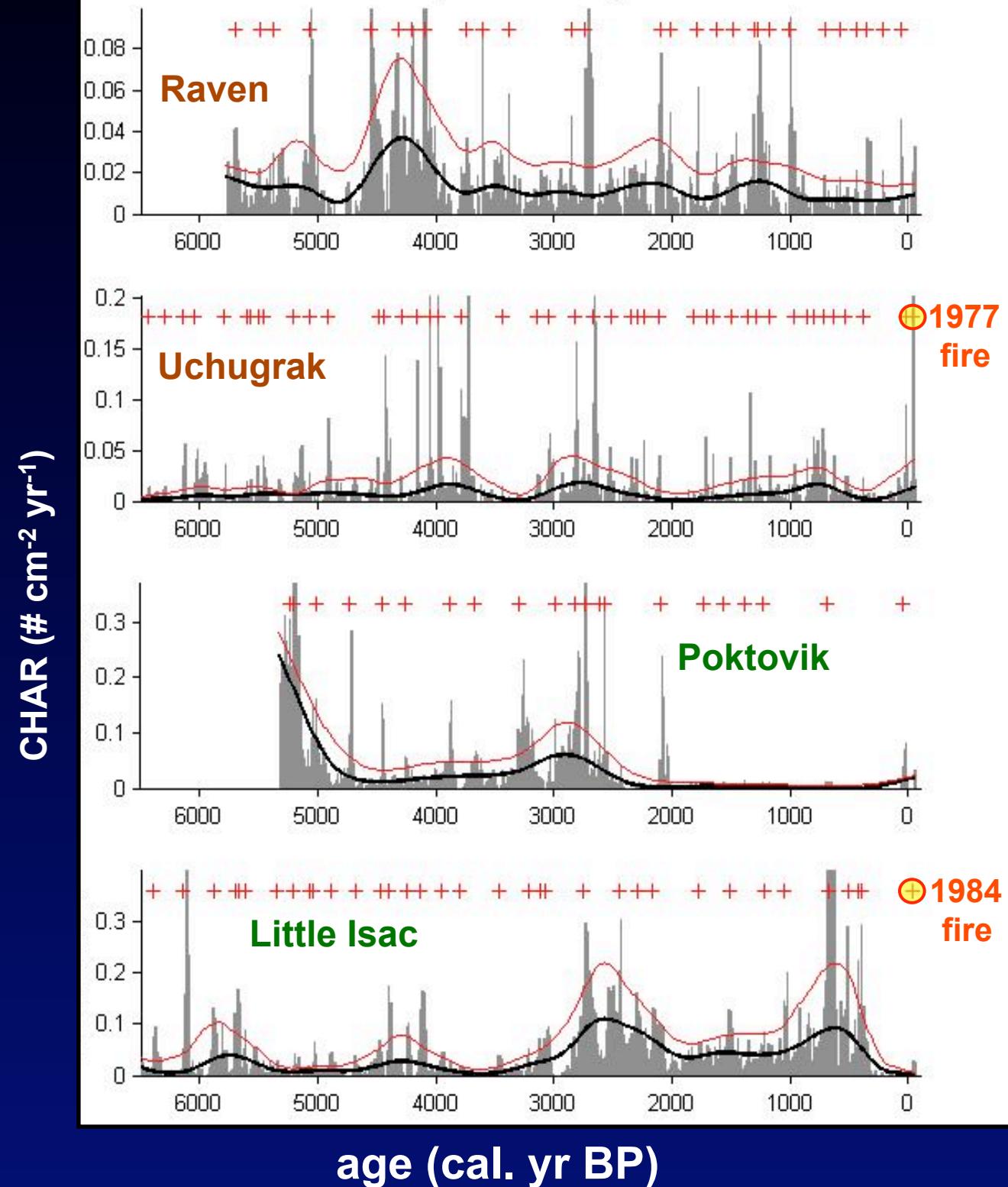
Age Models



Peak Identification

1. Tundra burns

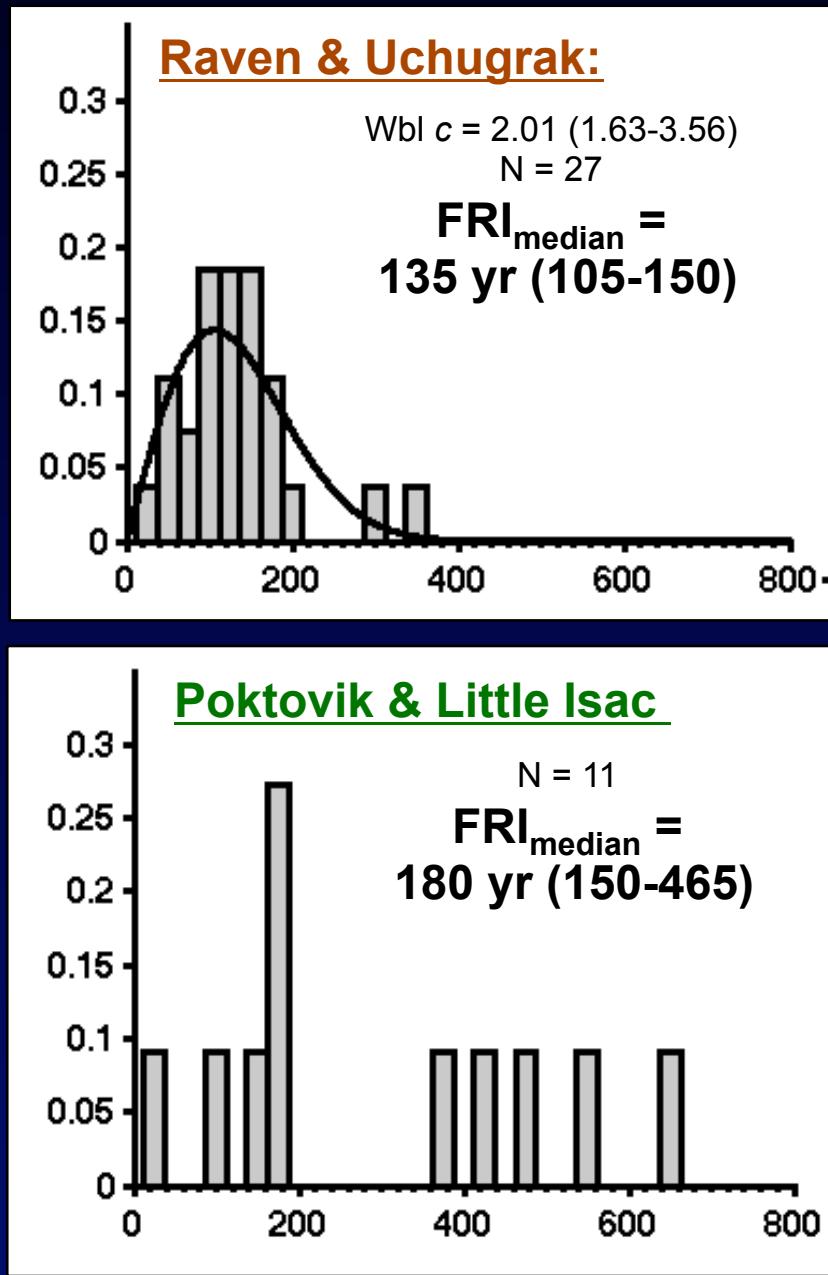
- Records appropriate for peak identification
- Recent large fires detected



Fire return intervals since 2000 yr BP

2. Location matters

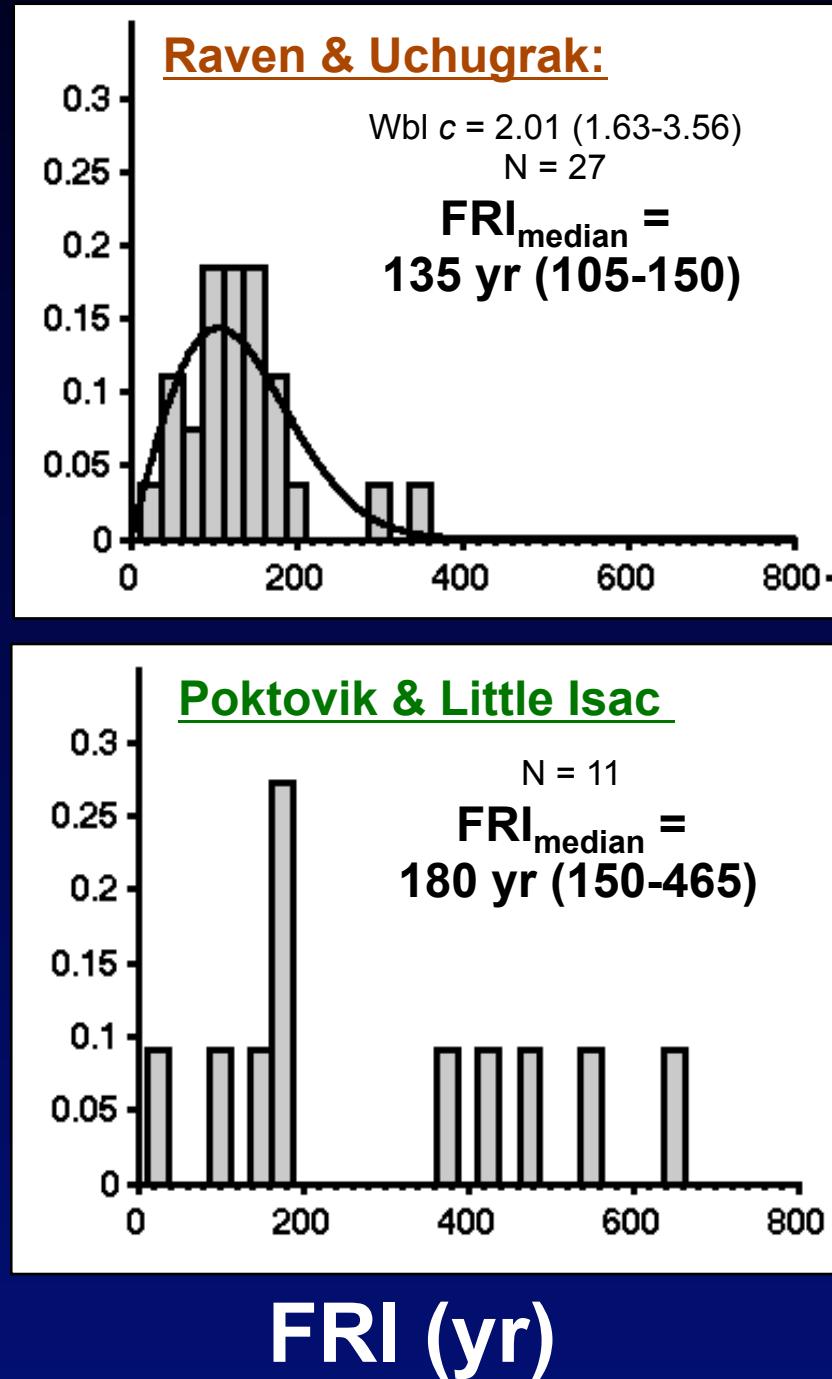
density OR proportion (x25)



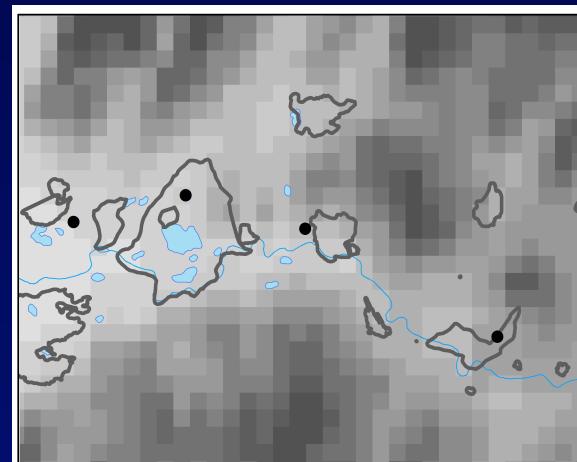
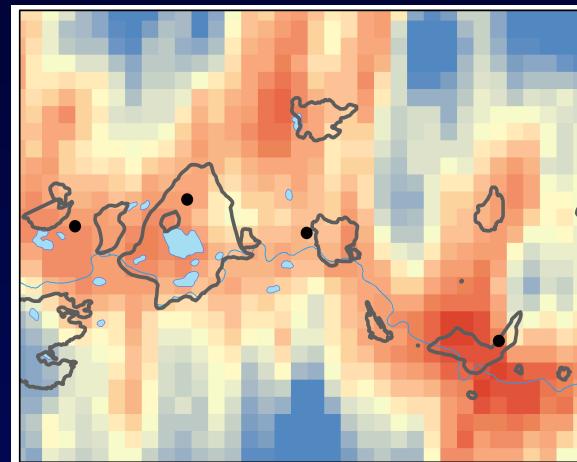
FRI (yr)

Fire return intervals since 2000 yr BP

density OR proportion (x25)

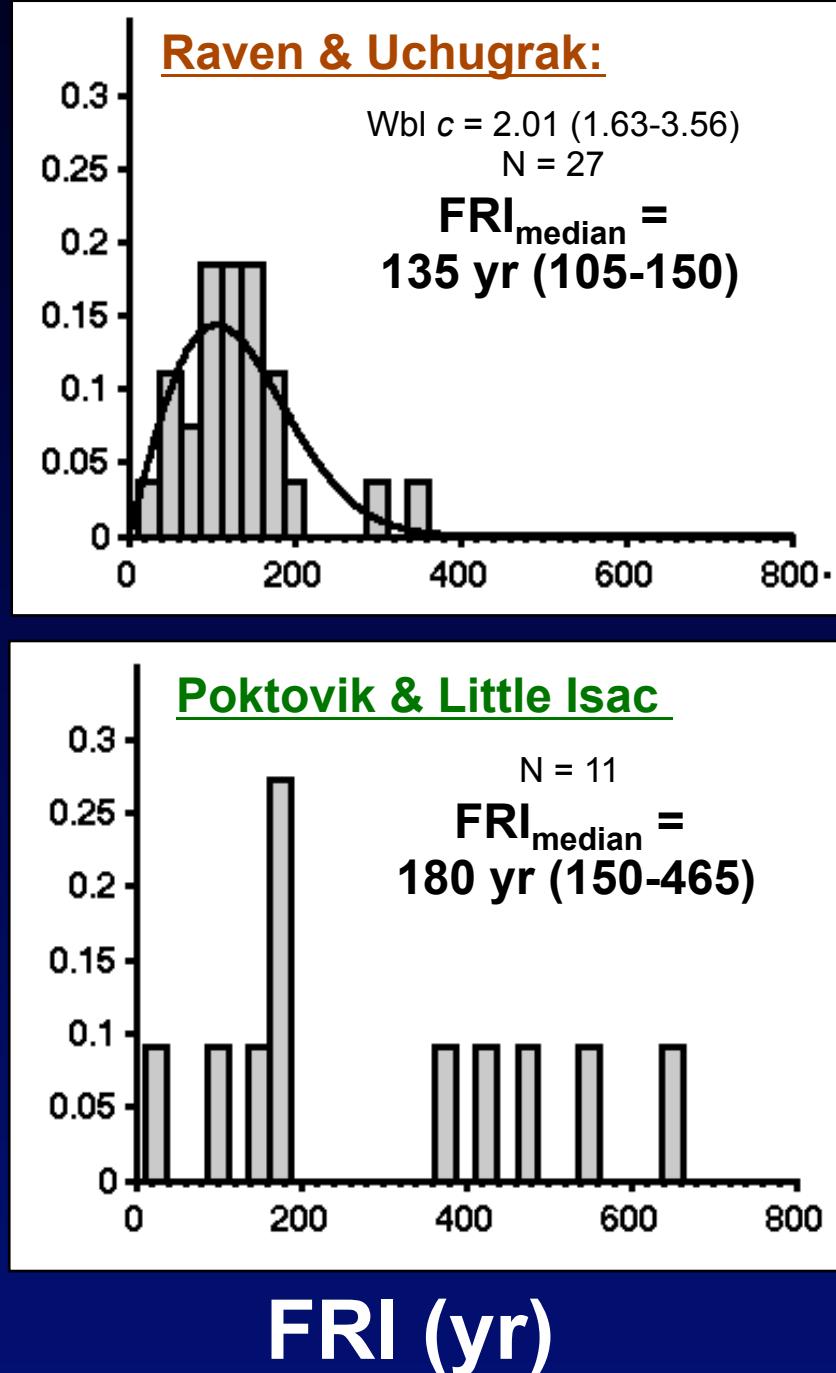


2. Location matters: ▪ climate



Fire return intervals since 2000 yr BP

density OR proportion (x25)

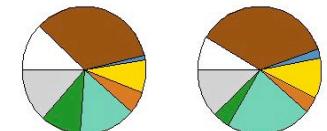


2. Location matters:

- climate + vegetation

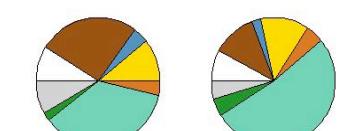


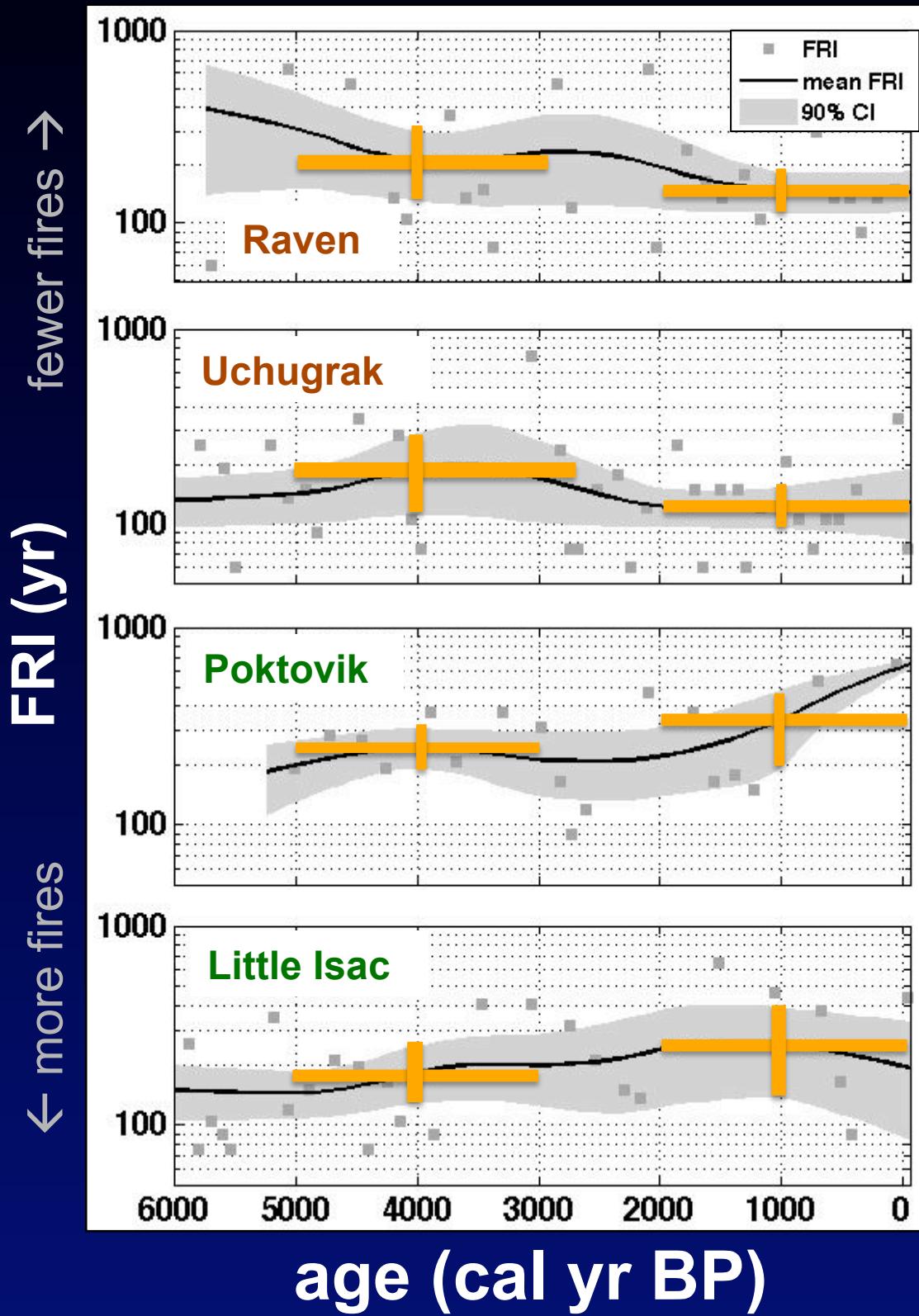
RA, UC:



Non-burnable
White Spruce
Dwarf Shrubland
Alder Shrubland
Willow Shrubland
Shrub Tundra
Tussock tundra
Other

PO, LI:



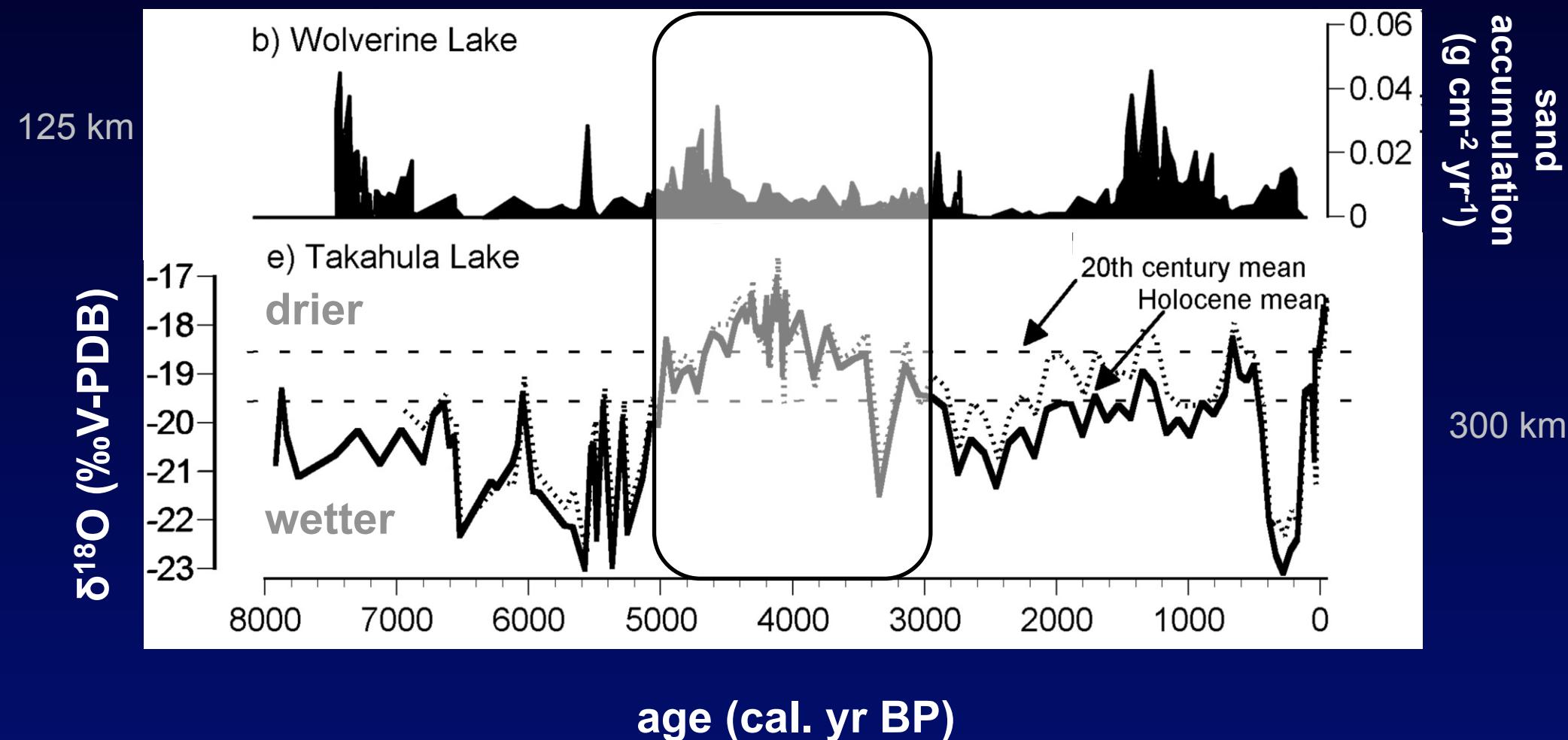
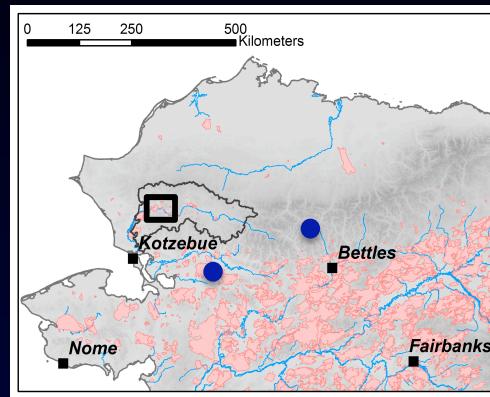


3. FRIs vary through time

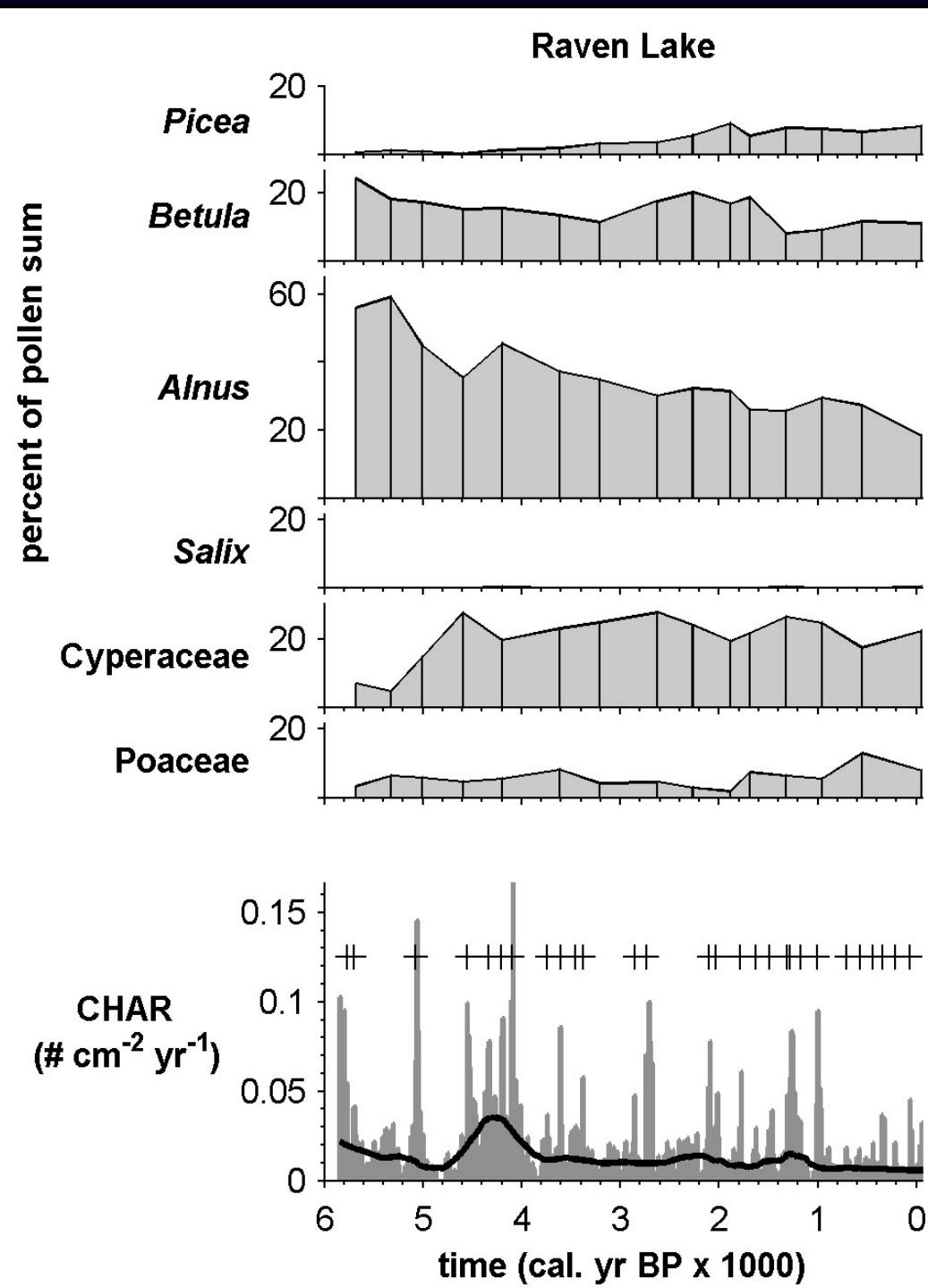
- At individual sites
- Between sites

site	4000 yr BP	1000 yr BP
RA	210	140
UC	195	130
PI	250	340
LI	180	260

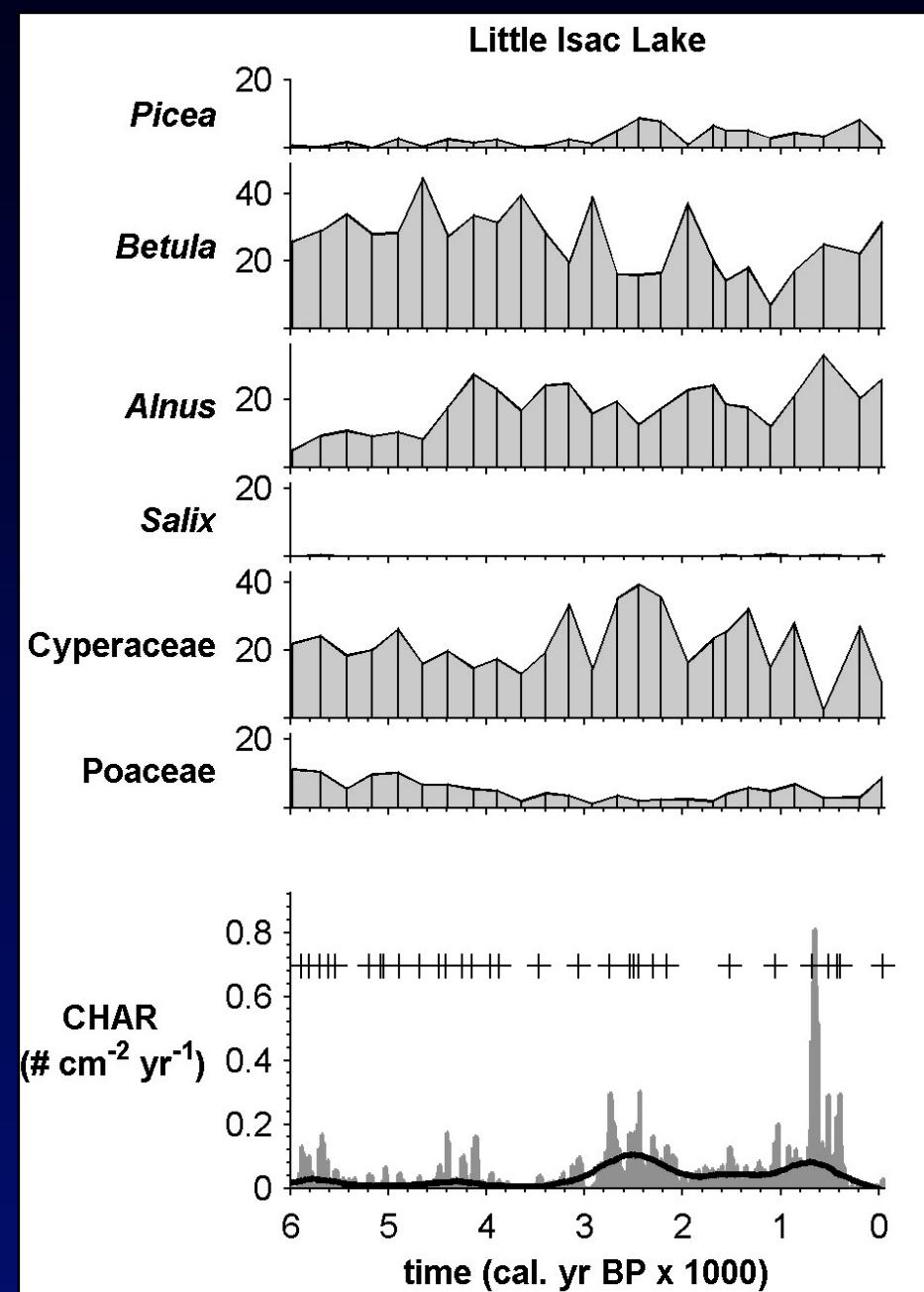
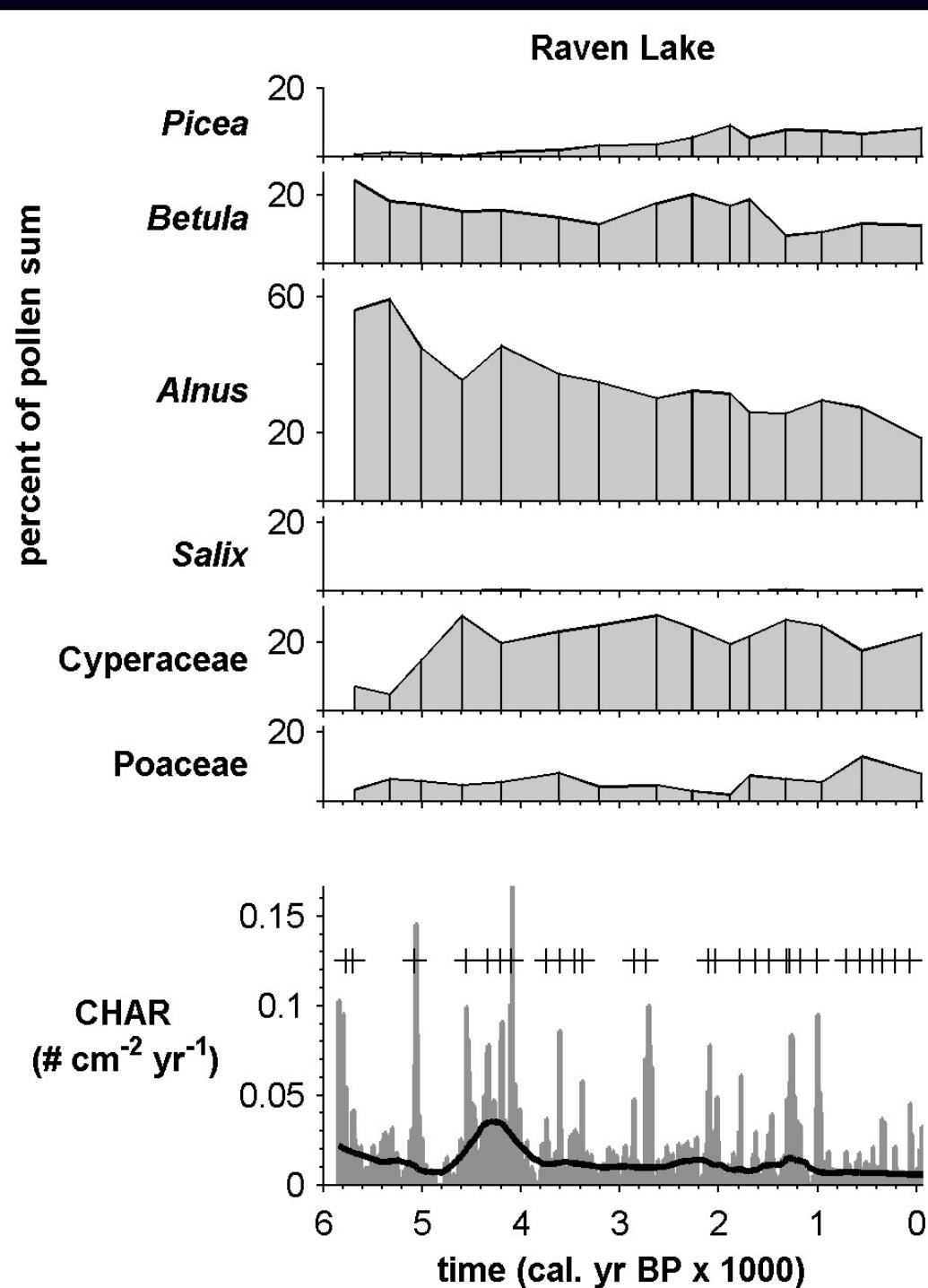
Holocene effective moisture



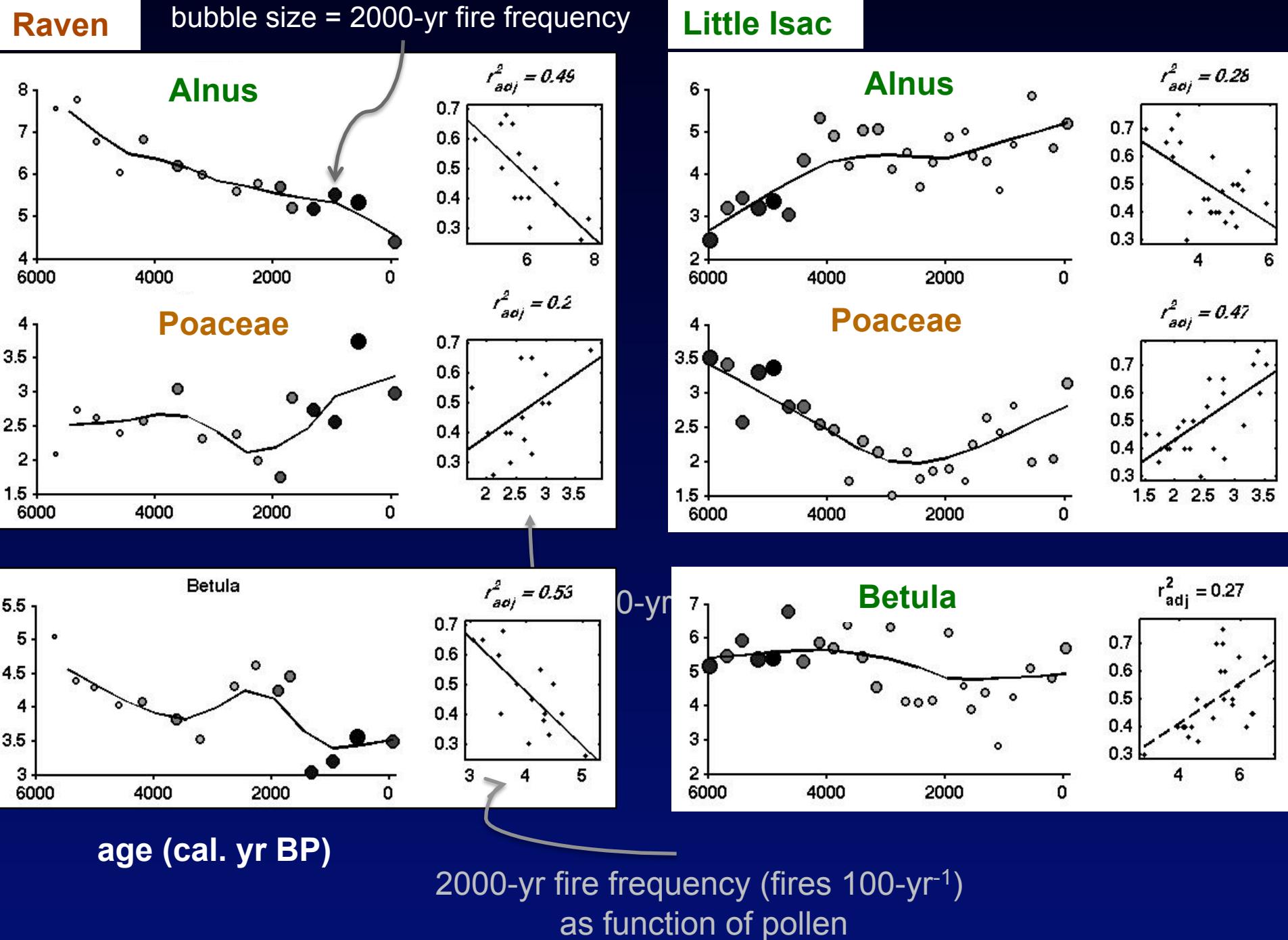
Holocene vegetation change



Holocene vegetation change



4. Fire frequency varies with vegetation



Summary

- 1. Modern geographic variability reflected in late Holocene fire history**
- 2. Fire frequencies varied through time: climate, vegetation, and local factors**
- 3. Tundra fire regimes are sensitive to environmental change**



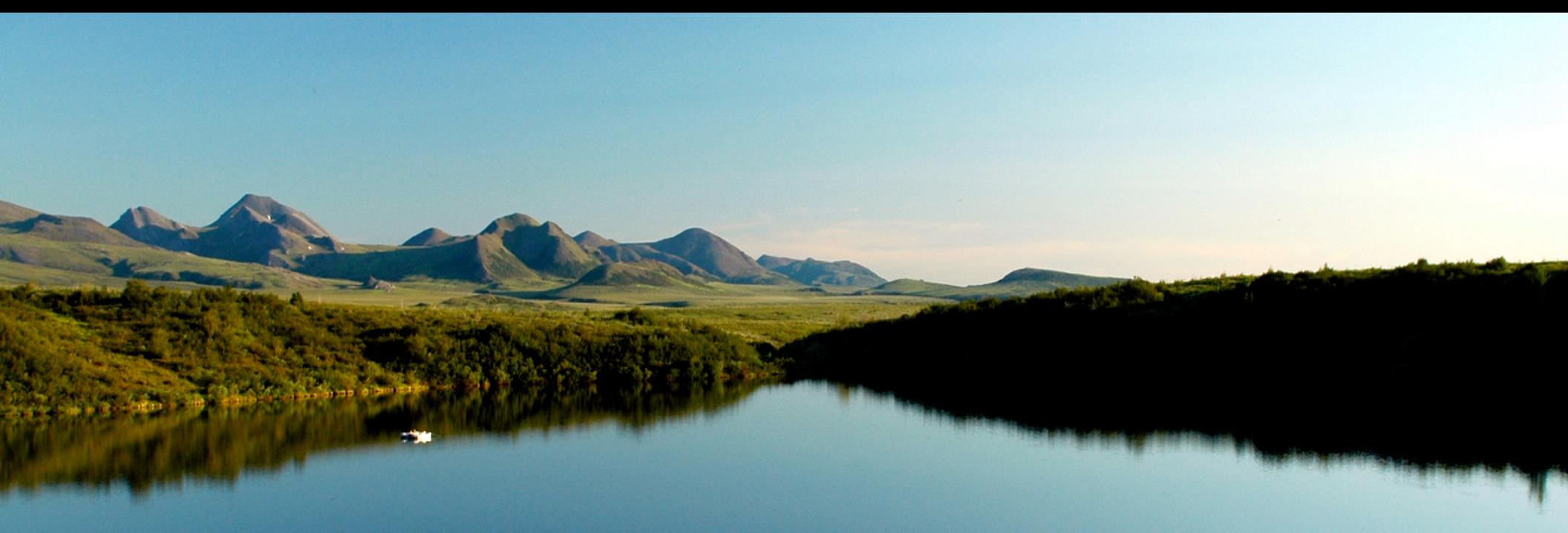
Acknowledgements and Questions

Funding: Joint Fire Science Program and the National Park Service.



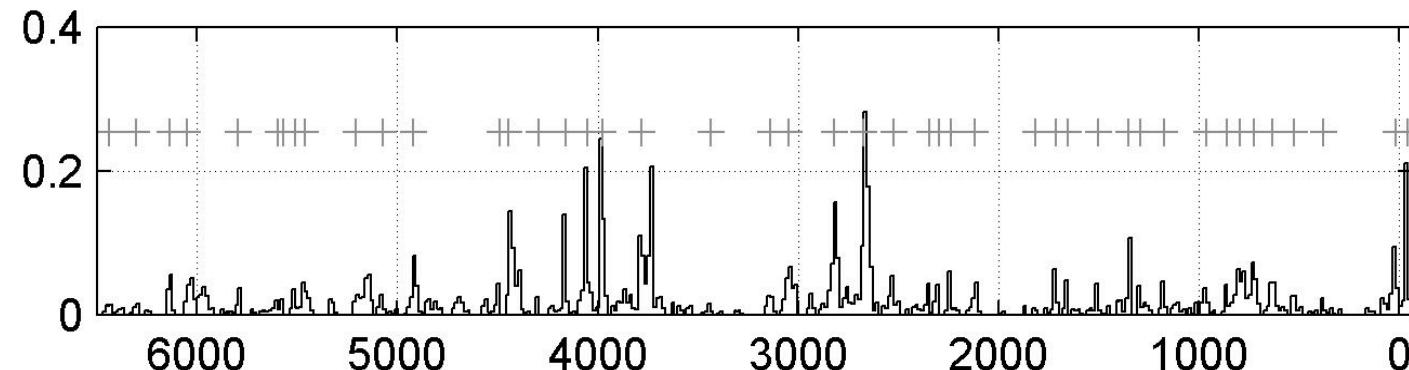
Field Assistance: Denali National Park fire personnel

Lab Assistance: Triet Vuong and Jennifer Schwarz



Temporal Scales of Change

CHAR (# cm⁻² yr⁻¹)



Uchugrak Lake

temporal scale (yr)

